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PROCEEDINGS OF THE PACIFIC NORTHWEST SYMPOSIUM ON WATER POLLUTION RESEARCH (9TH). RESEARCH IN WATER POLLUTION AND OTHER ENVIRONMENTAL HEALTH FIELDS

Edward F. Eldridge

Public Health Service
Portland, Oregon

April 1960

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PROCEEDINGS

# of the

NINTH PACIFIC NORTHWEST SYMPOSIUM

ON

WATER POLLUTION RESEARCH

RESEARCH IN WATER POLLUTION AND OTHER ENVIRONMENTAL HEALTH FIELDS

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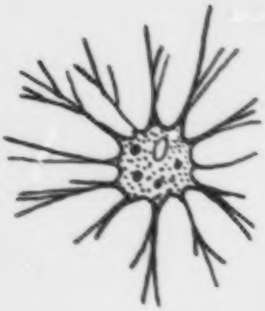

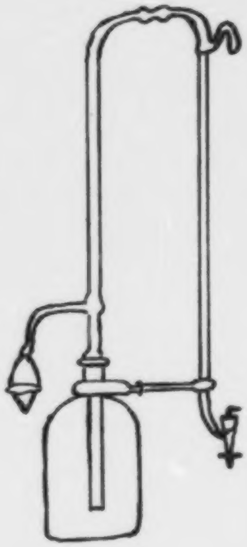

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Technical & Research Consultation
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U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE

Public Health Service

Region IX

Portland, Oregon

April, 1960

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NINTH PACIFIC NORTHWEST RESEARCH SYMPOSIUM

SUBJECT: **RESEARCH IN WATER POLLUTION AND OTHER ENVIRONMENTAL HEALTH FIELDS**

DATE: April 18, 1961. **TIME:** 9:00 a.m.

PLACE: Room 104, U. S. Court House Building, S. W. Main & Broadway, Portland, Oregon.

The Theme of the symposium was

THEME: A re-evaluation of research needs, facilities, personnel and financing in the field of water pollution and an introduction to other environmental health fields. The papers presented are reported.

AGENDA

9:00 - 9:15 Introductory remarks - E. F. Eldridge.

9:15 - 10:00 Opportunities for research and training for research in universities and colleges - Dr. Joseph McCarthy, Dean of Graduate School, University of Washington.

10:00 - 12:00 Water quality problems and required research--a panel.

1. Water supply - R. L. Culp, Consulting Engineer, Cornell, Howland, Hayes & Merryfield, Corvallis.
2. Public health - Wilson Bow and Robert Leavers, Washington Department of Health, Seattle.
3. Fisheries - Dr. W. P. Wickett, Fisheries Research Board of Canada, Nanaimo, B.C.
4. Agriculture - Dr. Rolf Skrinde, Associate Professor of Civil Engineering, Washington State University.
5. Industry - Dr. Herman Amberg, Research Division Crown Zellerbach Corporation, Camas.
6. Pollution Control - James Behlke, Washington Pollution Control Commission, Olympia.
7. Analytical (Laboratory) - Fred Burgess, Associate Professor of Civil Engineering, Oregon State University.

1:00 - 1:45 Problems and needed research in other fields of environmental health. Dr. P. H. McGauhey, University of California, Richmond Field Station.

1:45 - 2:30 Need for a system of information retrieval - E. F. Eldridge Physical Sciences Administrator, Public Health Service, Portland, Oregon

2:30 - 4:30 Financing of research and training facilities, equipment, personnel and projects. Ralph H. Holtje, Research Grants, Public Health Service, Washington, D.C.

PROCEEDINGS OF THE NINTH PACIFIC NORTHWEST SYMPOSIUM
ON
RESEARCH IN WATER POLLUTION
AND OTHER ENVIRONMENTAL HEALTH FIELDS

April 18, 1961

Assembled by

E. F. Eldridge*

Introductory Remarks - E. F. Eldridge

This is the ninth of a series of symposiums held in this area on subjects related to the field of water pollution. The first of this series on November 7, 1957 involved a general discussion of research with the aim of providing an opportunity for those interested in this field to become acquainted with each other and with the problems on which research is needed.

Since considerable time has passed and many changes have occurred since this first symposium, it seems desirable to repeat this subject. Our objective today will be again to look at the research needs in light of new problems, changes in concepts and an expanding field.

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*Physical Sciences Administrator, Department of Health Education and Welfare, Public Health Service, Water Supply and Water Pollution Control Program, Pacific Northwest, Portland, Oregon.

A great deal of emphasis is being placed nationally on an expanded research program in the water resource and related fields. Such a program is certain to have increased financial support through Congressional action. This interest of Congress is indicated by the report of the Select Committee on National Water Resources commonly known as the Kerr Report. This report states in its recommendations that "The Federal Government undertake a coordinated scientific research program on water." It is certain that much, if not most, of this research will be done at universities and colleges supported by grants and contracts.

It is appropriate, therefore, that we in this area evaluate our research programs, review research needs and become more acquainted with the mechanism of financing through grants and contracts. We hope that this symposium will provide the incentive for such evaluations.

FOREWORD

The Research and Technical Consultation Project was initiated in the Pacific Northwest in May of 1957 by the U. S. Public Health Service as a means of better reaching and serving those engaged in water pollution research. One phase of this project has been a series of informal symposia where an opportunity is provided for a free exchange of knowledge on subjects related to water pollution. To date, nine symposiums have been held in Portland. The following subjects have been covered:

1. Research Relating to Problems of Water Pollution in the Northwest
2. Financing Water Pollution Research
3. The Slime (Sphaerotilus) Problem
4. Short-term Bio-Assay
5. Siltation - Its Sources and Effects on the Aquatic Environment
6. Oceanography and Related Estuarial Water Problems of the Northwest
7. Status of Knowledge of Watershed Problems of the Northwest
8. Radioactive Waste Problems in the Pacific Northwest
9. Research in Water Pollution and Other Environmental Health Fields

Proceedings are compiled from the prepared papers and discussions. The following are the proceedings of the Ninth Pacific Northwest Symposium held in Portland, April 18, 1961.

RESEARCH AND TRAINING FOR RESEARCH IN THE COLLEGES AND UNIVERSITIES

Joseph McCarthy*

Mr. Eldridge, and Gentlemen, I have for many years had a rather substantial personal commitment to research relating to water and air pollution problems, and, therefore, it is a particular pleasure to be invited to speak today on research and training for research in the colleges and universities. What I have to say, I will try to make fairly general. However, my experience is very largely with the University of Washington and so the examples I give will often reflect University of Washington policies and procedures. But, I see before me many of my friends from other universities and I am confident that they will correct or add to my remarks, if necessary, to set forth information concerning the policies and procedures of their institutions.

The Role of the Universities

The classical organization of universities in the Middle Ages was into the four faculties; philosophy, theology, law, and medicine, and members of these faculties engaged in teaching and research as do faculties today.

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*Dean of the Graduate School, University of Washington, Seattle, Washington.

A new element of the role has been added in the United States during the last century. This is manifest in the passage of the Morrill Act in 1862. I believe, according to the Morrill Act, the land-grant colleges specifically and all colleges and universities to some extent added a third commitment to the basic tasks of the universities, the commitment of "Service" to the public. It is, I think, the undertaking to provide Service which brings representatives of colleges and universities here today to assist members of business and industry and government to find a solution to a problem of great public importance.

Special Characteristics of University Research

The universities of the West are now some 700 years old and they have survived as communities of scholars because of unique contributions in teaching research. To make these contributions in research, the maintenance of at least three conditions seems necessary:

1. Freedom of discussion. The research activity must be at all times open to discussion and criticisms. No confidential or secret research except possibly in relation to the national defense.
2. Excellence in quality of research.
3. Neutrality of position.

University Resources for Research

Many colleges and universities have extensive resources and facilities for research and I now propose to review these in categories.

1. The Faculty. Of course, the greatest resource is the faculty, those men and women associated with the colleges and universities who are experts in their respective fields and dedicated to the teaching - research - service activities that I have just mentioned. For example, the permanent faculty at the University of Washington comprises about 1100 persons in a wide variety of fields.

2. The Faculty Groups. The existence of strong departmental structures at many universities often leads to some shortcomings in faculty members in different fields or departments. For example, chemists may not talk enough to the mathematicians about their problems, although the mathematicians may be able to make major contributions toward the solution of these problems. The classical departmental organization may not always be best arranged to provide for solutions of today's problems.

To assist in finding solutions to problems involving several of the classical disciplines, members of the faculty may form themselves as special communities or groups to facilitate working together. For example, a Water Quality Research Group has recently been formed at the University of Washington and about six or eight faculty members are in the Group including Professor Sylvester from Sanitary Engineering, Professor Ordal from Microbiology, Professor Johanson from Chemical Engineering, Professor Barnes from Oceanography, and others. I am sure that representatives from other universities could report similar things.

3. The Professional Research Personnel. The development of research staffs associated with the universities is almost a Post War II phenomenon. The success of the synthetic rubber program, of the anti-malarial drug program, and of the Manhatten Engineering Works program demonstrated the value of maintaining close relationships between persons devoted full time to basic or applied research and persons devoted to teaching, i.e. really the teaching faculty and the graduate students. Some of the factors relating to the maintenance of research staff personnel at the universities, and specially the influences of federal funds, are set forth in a report which was gotten together by Dr. Glenn Seaborg and some others who comprised a Science Advisory Committee to President Eisenhower. This report is entitled something like "Scientific Research--Government and the Universities" and I think it is a very significant paper.

What this report says is that our society is now beginning to realize the full significance of what can be achieved by well planned and executed research activities. There is always a continuous spectrum of research programs which range from the immediate practical programs which must be solved tomorrow morning--either for profit, or for defense, or for anti-pollution--on through in a continuous fashion to very generalized problems which are just unplannable on a programatic or project basis. Solutions to these general and fundamental problems depend upon the initiative, the conceptions, and "hunches" of some individual scientist.

Now the development of research personnel and research institutes devoted to rather specific topics may, of course, take place quite apart from an academic institution. I understand that within the USSR there are a number of research and development organizations in Moscow and elsewhere that have no connection with universities or other educational institutions, although some of these research organizations seem to be quite high quality establishments. The point made in the Seaborg Report is the desirability of NOT separating the research institutes from the universities at least as far as basic research is concerned. Close relationships are needed. The basic advantage to be derived from developing research facilities in relation to academic institutions is because of the continuing emphasis on quality and questioning in the academic fields.

4. The Students: Graduate, Undergraduate, and Post-doctorate. The fourth resource is the students--graduate students, and to some extent, under-graduate students who may be able to function as part-time helpers in carrying out the research.

By students, I also mean post-doctoral students and this is another phenomenon that is to some extent new. We were astonished recently to find that some 300 post-doctoral students are at the University of Washington. These people are not teaching faculty, but they come and engage themselves in full time research with some faculty person in order to become still better familiar with some particular field. They come usually equipped with funds perhaps from Public Health or some other agency to provide for their own support.

You are, of course, already familiar with the graduate students and their research activity as assistants or in relation to theses.

5. The Spirit of Research. I submit that the research Spirit which often flourishes in the university atmosphere is a very real resource. Unless research people have a clear conception of quality and helpful criticism the program in the limit will turn out to be a rather routine kind of thing which moves not quite as far as you might have hoped. So the

research Spirit, the esprit' de corps in a group directed toward the solution of certain problems which are challenging is most important.

6. The Research Facilities. Now universities do often have extension facilities of many kinds. Some facilities are extremely costly and require a lot of know-how for maintenance and use. When possible, these may be made available by the university by virtue of their commitment of public service to assist in finding solutions for significant problems to the community.

7. The Academic Courses. Finally, I call your attention to the resource available in the academic courses offered by the universities day courses, night courses, extension courses and short courses.

So this is a recounting of some rather obvious resources which colleges and universities may be able to contribute by reason of policy and by reason of their basic commitment to public service.

Use by Business, Industry and Government of University Resources for Research

To work toward solutions of a problem of major public interest, how can one proceed to utilize these resources? Here

I really cannot avoid talking about rather specifically the viewpoint that we have at the University of Washington and what we have done about it.

Although our University and faculty have been active really for many years in assisting business, industry, and government, about a year ago we took an additional step and established an Office of University Research as part of the Graduate School Office. I have here today a number of booklets stating the nature of this organization and its policies. May I read briefly from this booklet:

> The University of Washington faculty constitutes a growing community of scholars of highly diversified interests and talents. Many faculty members have achieved distinction in fields which are of particular importance to business and industry: the sciences, engineering, and business administration. In many instances, the specialized knowledge of these men, the research techniques which have been developed, and the impetus of research programs already under way can be brought to bear upon special problems of business and industry; indeed the University has a long history of direct contributions of this kind to the economic welfare of the state. Less direct but equally essential services are rendered by the University in training men for work at the highest levels of professional competence, and--as an integral part of the educational process--in the conception and development of new ideas, techniques, and disciplines. The partial lists of departments and special laboratories or institutes given on the last pages of this pamphlet suggests areas in which the teaching and research endeavors of the University and the specialized problems of business and industry are often closely related.

> University research cooperation with business or industry usually takes one or two forms. In one of these, a faculty member provides advice or other assistance toward the solution of a business or industrial problem in accordance with the terms of a consulting agreement. In the other, sponsorship of a research project is assumed by an outside agency through a research grant or a research contract established between the agency and the University. The Office of University Research is prepared to assist in the initiation of either type of arrangement.

In order to bring university resources to bear on a certain problem, one of the difficulties is that there may be a large number of faculty members, and how are you to identify the specialist for your problem? Thus, one of the reasons for the establishing the Office of University Research was to provide a visitor to the University with some one place to go to locate the faculty man of interest.

Freedom of discussion in the university atmosphere, and constructive criticism of research that goes on is a vital part of the life and success of a university program. However, there are many individuals and industrial groups who may wish to have the advantage of some assistance from the university and yet not wish to have the results published immediately or at all. They may be interested in having the results maintained secret and confidential with respect to the particular sponsor. At this point, in view of the general agreement among universities that universities should not do secret research, one might say that nothing could be done. As a matter of fact, there is one important thing which can be done, i.e. the use of members of the faculty as consultants and this practice is well established in the universities throughout the United States. Our policy is clearly stated in the Faculty Code.

A consultation is ordinarily conducted off the campus. The professor may go to an industrial office or laboratory for conversations. It is expected that the amount of time that a faculty member devotes to consulting activity is modest, since he must be devoted primarily to his responsibilities centering around his teaching and research at the university. It is true that this takes away some of the faculty man's time from the university but this is balanced against the value of the help which he may be able to render to business, industry, and government, because of his specialized knowledge. Especially for professors teaching in professional fields, consultation may greatly stimulate the man. Incidentally, our university requires that the professor must seek approval for consultations in regard to how much time is to be committed and, in general, the field of the consultation. The fee or honorarium is not stated--this is a matter which is to be worked out by the consultant with the particultur people by whom he is engaged. But, it is definitely required that his primary commitment stays with the university. Thus the service of the faculty in consultations is an important contribution that universities can make and do make to the definition and solution of problems which must be considered and solved on a confidential and secret basis.

But, now suppose that the research needed involves no question of confidential activity. Here one comes into quite a different region which I want to discuss in the relation to research grants and contracts. This sort of activity has increased hugely since the end of World War II. For example, at our university there are at present some nine hundred separate research accounts, through which passes some $13,000,000 per year, with several thousand people engaged in the multitude of different research programs. To illustrate how these are initiated, suppose that a certain professor has a certain research interest which he would like to pursue and suppose this might be the identification and control of certain microorganisms in Green Lake in Seattle, which may cause skin afflictions to swimmers. He would then sit down and write a "proposal"--a paper addressed to whomever might be the grantor of the funds to support the activity, perhaps the Seattle City Council. In this proposal he would set forth the objective of his work, what he expects to do, what results he expects to obtain, and how much money he believes it will require to carry out the enterprise. If this professor happens to be in the Department of Civil Engineering, the proposal would be reviewed by the head of that department, by the dean of the College of Engineering, and by the dean of the Graduate School. In each case, the reviewers would look at the general nature of the activity, the matter of space for the activity, relationships with students, the type of apparatus that might be involved, if there are any hazards involved and, of course, the financial aspects. The person, the institution or group which receives the proposal can then study it, and accept it, and finally return it to the university for final acceptance by the Board of Regents.

Now I must speak of "indirect costs." This is a serious problem today at many universities. It is easy for the professor to write down that in order to do a certain research he needs say the part-time help of a graduate student, certain apparatus and supplies and travel to some site to collect information--these can be specified as "direct costs." But his laboratory is expensive to maintain and janitorial service, library service and heat and light must be provided. These are "indirect costs." Many research grants and contracts provide for payments of indirect costs. But some do not and this is a real problem in the universities today. There are two courses of action. One is to refuse the research grant although the activity may be very dear to the heart of some professor. The other course is to absorb the indirect costs, but with what? Universities have very limited uncommitted funds so only a few such grants can be accepted.

In a general way I must emphasize that the colleges and universities just must receive grants providing for the total cost of research activities contemplated. The indirect costs, of course, vary, but according to the U. S. Navy auditor, they run about 40% of salaries and wages as a rule of thumb, or to 15% or 20% of the total direct costs.

Now when the research grant or contract has been established, then the faculty person who is principal investigator moves ahead to do whatever he said he would do and some of the commitments in grant and contract proposals are very specific, while some are very general. It is, thus, this grant and contract research activity which provides a second way of operation of the Office of University Research.

Training for Research

Essentially the training for research is provided to graduate students as well as to others who may take certain specialized courses. It is, of course, desirable that the graduate students be worked into the research activities conducted by the universities as much as possible. But the question of the research topic arises. In nearly all universities graduate students are not assigned to topics. It is expected that a graduate student will have enough intelligence and initiative himself to select a research topic and work out a plan and program.

This means that if graduate students are to participate in grant and contract research, then the field must be one of interest to graduate students. This is a delicate problem. Certain types of problems interest the mathematicians on an absolute basis; then you have a total spectrum of different kinds of problems that may come down to some very immediate practical ones. There is scope in today's universities for a very wide variety of research, but the feeling in different faculty fields varies about the conceptions of fundamental versus applied research.

In one department at my institution, at the beginning of the year each new graduate student is given a booklet setting forth in summary form several research topics suggested by each member of the faculty in that department. There are about 20 to 30 topics listed. The student is asked to propose his own topics also. The student discusses the topics of interest to him with faculty members and he reads the literature. He then proposes in order of his choice the topics of maximum interest to him. So long as faculty time and laboratory facilities permit, the student is given his first choice. He may or may not choose something that has anything to do with a research grant or contract, so the subject matter of the research to be supported by a grant or contract is of much importance to universities in relation to their graduate student relationships.

For the research program, I have been designated as the principal investigator and, at present, there are two associate investigators, i. e. Professor L. N. Johanssen in chemical engineering and Professor Loren Donelson in fisheries. One full time co-worker is Dr. B. Hrutfiord whose field is organic chemistry and, in addition, a number of graduate students are conducting research sponsored through the NWPPA funds.

Several activities are now being prosecuted. Work is being done to develop at this time a generally acceptable standardized method for determination of concentration of spent sulfite liquor. Spent sulfite liquor processing to provide for disposal by evaporation and burning, or in manufacture of useful products is being studied. Kraft pulp mill effluents, both gas and liquid, are being investigated, including both analytical and processing aspects. Fundamental research is being conducted and directed toward securing increased knowledge, particularly of lignin, because if we knew more about this substance and how to use it profitably, it would certainly provide a powerful impetus to move very rapidly toward the collection and profitable use of spent sulfite liquors. Work is beginning in the fields of aquatic biology. Over the life of this research program, funds amounting to more than $600,000 have been provided by the Northwest pulp and paper industry and expended moving toward the solution of a major problem in water and air pollution.

These, then, are some general comments concerning the use of university resources in working toward the solution of a problem of great public importance.

Example of Use of University Resources

Finally, I wish to speak very briefly about one specific use of university resources to move toward solution of some of our pollution problems. This is the Pulp Mills Research Program at the University of Washington with which I have been associated personally for a long time. This program was initiated some 17 years ago and it still continues today. When the program was started, there were three objectives, and these were:

1. the development of sanitary engineering type of processing for the disposal of spent sulfite liquor effluents and other effluents,
2. the development of useful and salable products made from effluents of pulp and paper mills, and
3. the securing of new fundamental data in the fields of chemistry and chemical engineering of wood and its components and conversion products.

This same pattern exists today except that one additional objective has been added, i. e.

4. the securing of additional information about the characteristics of waters in relation to biological systems--the capacity of waters for multiple use, etc.

The funds provided to support these research activities at present amount to $35,000 per year. This sum is provided through the Northwest Pulp and Paper Association which is made up of approximately twenty separate companies in the Northwest who contribute to the research in relation to the amount of wood pulp produced.

The graduate students at our institution serving as assistants and teaching assistants receive a stipend of $225. per month. These people are expected to work at least twenty hours per week. Out of the $225. per month, they pay tuition which amounts to some $213 per nine months for residents of the State of Washington. The student is, of course, expected to come forth with a thesis or dissertation in due time. Insofar as student relationships with research grants or contracts are concerned, it is expected that the thesis research activity will go ahead steadily without being held back in any way by the existence of the research grant or contract. There is no question of the student withholding his thesis for a year or two. When ready, the research results are to be submitted immediately to provide for freedom of discussion and criticism. The same applies to publication.

The achievements of the research program have been recorded in a large number of reports and papers published in the scientific and technical literature. This new knowledge--which is what one should expect from universities--assists industry to move as feasible arrangements are established.

The decision-making mechanisms are outside the university and, of course, should be so.

This Pulp Mills Research program has stimulated the development of related activities. For example, several Fellowships are maintained at the University of Washington to provide support for graduate students interested in wood chemistry and related fields. Such Fellowships have been granted by the Rayonier Company, The Weyerhaeuser Company, the Hooker Electrochemical Company, and others. This type of support provides for the production from the universities of highly capable research men as well as of the research results themselves.

The Future

Finally, a word about the future. If you look at the graphs that exist today reflecting the scale of the research activities that are being conducted at universities, and the rate of change in these activities, there is no question but that these research activities will continue and expand. Around the United States, the universities do recognize obligations to work with the communities, the governmental agencies and industries in moving toward the solution of problems that are of public interest even if they are not directly part of the classical teaching and research activities of the universities. The universities have, in a sense, taken on a new role and this is the role of research in the public interest as well as research as a part of the educational process and to provide new fundamental knowledge.

The water and air pollution problems which are before us today will be mitigated in the future by the contributions from many persons and organizations, and, along with other organizations, the universities will make major contributions "pro bono publico."

DISCUSSION FOLLOWING DR. McCARTHY'S REMARKS.

STATEMENT: There is one additional degree of freedom and one additional restraint. The restraint is that we largely undertake only those projects in which an individual faculty member is particularly interested. The other degree of freedom in the case of research is in the development and use of university faculties, as well as graduate students. At the University of California, and several others, research is undertaken and graduate students employed as professional workers, even though it may never lead to their own particular dissertation. This may be poor education, but where possible, the graduate student is allowed to work on a project.

This service function that Dr. McCarthy pointed to introduces more and more of the type of research that may not be suitable for doctoral dissertations but is admirably suitable for work of graduate students. As a final remark, the university should insist that the work shall contribute to the educational effort and keep away from conflict with the professional research organization that does service only.

STATEMENT: There is one other point that should be mentioned. It is related to indirect costs, but it is not the same. This is the question of allotting the cost of the space in buildings. The educational institutions represented in this room all have some common problems and one of these is the question of space, square footage of laboratory space. It is difficult to allot this cost to individual projects because it comes in million dollar increments. The matter of construction costs--capital outlays to provide laboratory facilities--must be taken into account when financing research at educational institutions.

STATEMENT: As one who operates a small but interesting business in this field of research, I would like to proffer the opinion of a private consultant. I have worked on a Committee of the American Institute of Private Laboratories for a number of years and refer you to an article in the literature dealing with the research policies as related to private consultants, "Chemical Engineering News," April, 1946. This policy was the result of discussion of people on both sides. I think it is a good policy statement since it establishes a line between the type of research which should be done by public institutions and that which should be carried out by private concerns. There need be no unfair competition. It is my opinion that public agency facilities should be used for the benefit of the public, not for individuals or private business.

It has been very difficult for universities, sometimes, in drawing up policy to recognize this point and to delineate it in their policy statements.

A second point is that the results of research should be available to all interested persons during and after the work is completed.

DR. McCARTHY'S ANSWER: Our institution is very mindful of the significant role of the private laboratory and the private consultant. We do maintain effectively the policies that you mentioned. We think that the taxpayers' money that goes to buy the buildings and pay the faculty salaries should surely provide the product that would be in the general public interest and not be competitive with any particular profession.

With respect to consultation I would have to say that the people particularly engaged in professional schools may go to "seed" to some extent if not allowed to do a reasonable amount of consulting. I mean that they need some continuing relationship with the practice. So, we think some modest consulting is good, is stimulating, is helpful to the educational program. Basically we hope to maintain a policy that is really non-competitive. We do not undertake that kind of research where there already exists private facilities capable of doing it. This is our policy and is really nearly the policy of all universities around the country.

Let me say just one more thing about the security question. We were concerned about this proprietary research aspect and so we did an informal poll around the country. We contacted some thirty-nine members of the Association of American Universities in the United States, including an array of leading institutions. We have a reply from everyone of them. These replies indicated that there were only two which would in fact do as part of the university structure what is confidential private research for particular individuals. The others would not.

PANEL DISCUSSION - WATER QUALITY PROBLEMS AND REQUIRED RESEARCH

WATER SUPPLY

Russell L. Culp*

Any consideration of practical water supply problems ultimately involves the question of economics. Water is a renewable resource, and is subject to reuse. Water can be made available for use anywhere on the globe for a price. The price is determined by the cost of processing and delivery. The charges for production and transportation often determine the purposes for which water may be used. If there is a choice among several sources of supply of nearly equal quality, the water consumer will normally select the source which is cheapest. These are a few of the reasons for the contention that economics is basic to any discussion of water availability.

In the time available it is not possible to consider individually all of the water supply problems which deserve mention. Therefore, it becomes necessary to generalize or summarize, or to select a few of the most important items for detailed examination. One approach to this situation is to talk about the "national water problem." This is a very difficult and hazardous undertaking for the reason that there is no national water problem per se. Actually the national water problem is an exceedingly complex composite or total of a great number and wide variety of local or individual problems. Many of these problems arise as the result of increasing use from a limited supply, or from increasing pollution of a source of supply. The best solution for a particular water problem almost always requires the tailoring of general principles and methods to suit the special set of circumstances at hand. The number of variables involved is usually so great as to defy the successful application of blanket solutions or "cook-book" answers.

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The newspapers carry many stories of dramatic attempts to solve the "national water problem" at one fell swoop by the desalting of sea water, or by "criss-crossing the country with giant pipe lines." These stores point to the almost universal availability of brine or brackish waters, and to the existing system of pipe lines carrying petroleum products to all parts of the country. The inferences here are that the perfection of demineralization processes or the construction of cross-country water pipe lines offer potential solutions to all water problems. Surprisingly, these proposals have great public appeal, despite the fact that their limitations are obvious to scientists and engineers. Even the most cursory economic evaluation will show that the demineralization of salt water will probably never solve more than five per cent of the nation's water problems, and that the country will not be served by a nation-wide system of water pipe lines unless the price of water approaches that of oil. This is not to indicate that development of demineralization processes should not be continued, since this research is certainly very worthwhile, and more funds could be used advantageously in this area. Rather, it is intended to emphasize the need for vastly expanded research in other aspects of water supply which offer promise of more widespread application and greater returns in providing more and better water for use at a lower cost.

Research is presently a magic word in industry. Large sums of money are spent each year in developing new products and better methods for making old ones. This investment is returned many times over to industry in the form of additional income or greater profits. Comparatively, the funds spent annually for water research are extremely small. Because most water research is, and probably will continue to be, sponsored by public funds, it is doubtful that the per cent of total revenue from water sales spent for research will ever equal that invested by industry. But certainly some expansion of water research beyond the present low level must be accomplished in order to assure reasonable progress.

Research in water works engineering surely is destined to become a more important factor in the future than it has been in the past. Historically, progress has depended upon accumulation of experience and experimentation, or empiricism. This approach will continue to contribute much to advancement, but the art of water treatment must be broadened to utilize scientific research methods to increasing advantage. Future research should give a better understanding of the fundamental processes and methods now in use, so that they can be applied more economically. Research should also reveal entirely new techniques which will provide fresh approaches to water problems. In the past, the most important water-related research has been concerned with health. This will continue to be important as more is learned about viruses, the effects of trace substances in water, and similar subjects. But the greatest future challenge lies in the concept of conservation and reclamation. The fresh water resource must be more fully and efficiently developed for use, and better procedures must be devised for the reclamation and reuse of water.

Presently, only a part of the nation's total fresh water supply is put to beneficial use. In seasons of heavy precipitation and runoff, vast quantities of water flow to the oceans virtually unused. Storage of these seasonal excesses in locations where the water can be used conveniently and economically during sub-

subsequent dry seasons will effect a substantial increase in the available water supply. This is, of course, an old concept, but one which must find ever-increasing application in the future. The accumulation of more basic data to accurately define the seasonal variations in the quantity and quality of surface water flows is essential to the sound planning of reservoir storage projects.

In some climates the water loss by evaporation from the surface of storage reservoirs is important, and further research to find means of suppressing evaporation losses will increase the net yield of reservoirs.

In many places the water in rivers is used several times during its travel from source to mouth. Each user diverts flow for use and returns a substantial part of it to the stream for subsequent reuse downstream. This is accomplished by proper treatment of wastes, utilization of natural stream purification capacities, and adequate water treatment. In a few instances, the total diversions from a stream may exceed by a factor of five or ten the total minimum stream flow. Undoubtedly, methods for the reclamation and reuse of water will be extended and improved upon in the future, and this is a fertile field for research.

There is an urgent need for more rapid, preferably instantaneous mechanical methods for the chemical and biological testing of water and wastes, and for the development of other automatic instruments for plant control. The limited market for new instruments designed specifically for water supply purposes is not attractive to manufacturers. The potential benefits to water users is great, but individual water purveyors are not in a good position to undertake instrument development on their own. It appears that most of the automatic instruments of the future for water plants will continue to be adaptations of industrial equipment, unless the water works industry as a group, or federal agencies find means of supporting research in instrumentation.

If substantial savings in water production and distribution are to be realized in the future, radically different methods must be devised. This means a departure from tradition. Since public health is involved, acceptable departures must be based upon adequate scientific evidence and sound engineering principles. The water works industry is now on the threshold of major breakthroughs in rapid coagulation, high-rate filtration, and other processes, and in the development of new and improved materials and products. Promising leads in these areas should be pursued with adequate research programs.

These are but a few suggestions for problem-solving research. Additional ideas are listed at random below:

1. Effects of irrigation return water.
2. Better protective coatings for pipe lines.
3. Detection and removal of pesticides, herbicides, and other organic chemicals.
4. Methods for automatic predetermination of coagulant dosages.
5. Recovery of alum and other treatment chemicals from sludge.
6. Electronic reporting of customer water meter readings to a central station.
7. Corrosion control.
8. Physical properties of plastic pipe.
9. Iron and manganese removal, particularly the basic physical chemical reactions involved.
10. Changes in water quality in distribution systems.
11. Rapid bacteriological testing by use of radioactive carbon or other tracers.
12. Further studies of the biological uptake of chlorides for possible application to desalting.
13. Studies of water hammer.
14. Algae removal.

15. Improved taste and odor control.

16. Relationship of filter properties to filter performance.

17. Study of adsorption phenomena.

18. Methods for more complete removal of synthetic detergents.

19. Improved leak detection devices.

20. Water resources management.

21. Toxicity of trace elements and compounds in water.

Many additions could be made to this list.

A searching and comprehensive analysis of water problems followed by research oriented to their solution can contribute greatly to the understanding which is needed for maximum beneficial use of water supplies. In addition, new developments in other fields should be continuously reviewed for possible application to water works practice.

The nation's fresh water resources are more than adequate for all future requirements if they are developed more fully, managed more wisely, better conserved, further protected from pollution, and more efficiently reused.

PUBLIC HEALTH

ROBERT E. LEAVER*

Harry Jordan said in the Conference on "Man versus Environment": "That if we ran with the solution of the unknown chemical compounds in water twice as fast as we now are, we could at least stand still."

In outlining the water quality problems in public health, we can break them down into five categories: Source, Treatment, Distribution, Evaluation, and Legal.

Source

1. What effect will the storing of water over organic swamp material have on the water quality?

   Tacoma and Seattle are faced with this problem because of new dams and because the areas involved are small. Seattle is planning to remove the organic material. In Tacoma the final answer is not decided. Research at the University of Washington financed by the Corps of Engineers is underway but not far enough along to be evaluated. The drainage from ditching of the swamp on the Tacoma watershed caused a taste and odor problem during construction. More work and evaluation may be necessary in this field.

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2. Pressure by recreational and sports groups for the opening of closed watersheds to obtain more recreational area has made it more and more important to properly evaluate the effect of recreation on public health and water quality.
    a. Will a community's water supply be kept free from the hazard of virus and bacteriological contamination if the public is allowed on the watershed? When treatment is simple chlorination? Filtration? Complete treatment?
    b. Does a fire on the watershed endanger the water quality? Is the fire hazard affected by public access?
    c. How much is it worth in recreational value to open a watershed?
3. Certain island areas in the Pacific Northwest are in need of better methods of obtaining fresh water from the ocean or atmosphere, e.g. desalting, atmospheric extraction. The proper development of large areas is partially held up pending the availability of reasonably cheap fresh water.
4. The increased use of detergents, insecticides, fertilizers and agricultural poisons is already creating a potential problem in the Pacific Northwest and particularly so in the eastern part of Washington (3), yet the techniques are not now complete enough to identify all of these compounds as they may occur in a water supply. Preliminary work at the

University of Washington on the natural breakdown of some of the organic compounds indicate that they change little in their passing through natural purification processes. Research will have to be done to establish limits of dangers and uses, such that we don't create more problems than we solve with these organics.

5. Water from more and more wells in the Pacific Northwest is becoming unacceptable for industrial and domestic use. The cause and correction of well failures is in need of study. The Public Health evaluation of recharging of wells is not complete.
6. Per capita water use is going up. A study of water needs in this area 10 - 20 - 30 - 50 - 100 years hence is needed to protect future public health interests.

Treatment

1. Better and more effective iron removal systems are needed. Proper iron removal is becoming more necessary as water needs increase. Large areas now have poor quality ground water that will have to be developed and treated.
2. There is need for simple small automatic filter plants at a reasonable price to treat surface water. For example, one of the manufacturers has developed a portable 5 gallon per minute, complete settling, open sand filter plant with

chemical feeders that will backwash automatically, which looks promising. Further evaluation and development is needed in this field.

3. There is need for more evaluation of the effect of chlorination on virus, particularly Hepatitis. Recent experiences have raised many questions which must now be studied. Our whole public health concept of safe water could be changed if chlorination is not as effective as we have previously assumed. The validity of using MPN to include "virus" safety should be re-evaluated and if it is lacking or questionable, a new "virus" yardstick should be developed. Explore the life expectancy of virus outside the human host, and the paths the virus may follow and what treatment hurdles it may evade in a presumed path to a human being who may be adversely affected by it.
4. Recognizing that the human factor is vital to safe water, there is need for more in-service training of water works personnel. A correspondence course for sewage plant operators has been helpful and could be started for water works personnel. Water works personnel certification could be extended to all states in this area to help raise standards of operation.
5. Better means of evaluating treatment are needed. For example,

simple accurate color and turbidity equipment. Simple screening tests for organics, radioactivity, trace minerals, etc.

6. Research on Nematodes to completely evaluate any problem is needed.
7. Evaluation of high rate filtration and control methods as practiced at Richland and Pasco is desirable.

Distribution

1. The proper cooperation of fire interests and Public Health, in many cases, is not coordinated enough at all levels of government. Well informed public health review of water works plans could improve fire flows and Rating Bureaus could help locate and eliminate public health problems. Coordination and more common standards as to main sizes, cross connections, etc. is needed.
2. More research on paint and primer toxicity to water is needed and better distribution of present information to manufacturers and users.
3. Proper evaluation of water quality deterioration in distribution systems is needed.
4. Better and cheaper methods of covering water reservoirs to exclude dirt and light.

Temporary methods of preventing bird contamination as an interim measure.

In the Pacific Northwest area, the covering of all finished water reservoirs is long overdue, and the problem of bird contamination often underestimated. Two cities in Washington have not met current bacteriological standards during 1960 because of birds.

5. Civil Defense public health emergency water supply operation is still in need of practical planning at all levels.
6. A basic model law for state adoption to eliminate dangers of cross-connections is needed.
7. Better and cheaper methods of building and operating water systems in perma-frost areas is needed.

Evaluation

1. Simple radio-activity evaluation equipment and techniques to use as a tool for local water departments is needed. Special industries served by public water systems have had problems, and communities have become unnecessarily concerned because of the lack of proper local evaluation.
2. More specific laboratory tests than MPN are needed to evaluate health hazards, especially so in the virus field. (2)
3. For more use of machine records in the water works record an evaluation field is needed. Techniques of use should be worked out.

4. Screening and evaluation tests for trace elements as partially outlined in (2).

Legal

1. A model law on the public health aspects of a state health department's water program.

To summarize: "We have not succeeded in listing all of the problems. Indeed, I feel we have not completely listed any of them. The problems and needs we have found only serve to raise a whole set of new questions. In some ways I feel we are as confused as ever, but I believe we are confused on a higher plane above more important things." - Anonymous.

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FISHERIES

W. P. Wickett*

The first symposium in this series, held in 1957, called for more knowledge of the biology of the organisms and of the environment. The same need is present today; for as more knowledge has been gained so we realize the urgent need for detailed information in many fields. Administrators must decide how much we will pay now for knowledge or how much will be left for following generations to pay for unwise resource use and the handling of coastal waters and streams as though they were non-renewable.

Let us look at some general concepts that have become available to us. Pollution takes place when the environment is changed beyond the range of adaptability of the species of aquatic animals under consideration. The range of adaptability to any one factor varies with the past history, the age, the state of the animal, and the level of environmental factors, such as salinity, oxygen, temperature, turbidity, space, etc. Knowledge of the ranges of environmental factors that permit the continuity of the species is necessary, and these ranges may differ from laboratory determinations. A combination of data from both the laboratory and from natural state is required.

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Studies in the past ten years have shown that both metabolism and activities are affected by the environment. Lethal levels differ from levels that allow activity. Behaviour itself differs from one set of conditions to another. This has led to a new concept of defining optimal levels of interacting factors. The mathematical treatment of Box of Great Britain provides the guidance needed. No longer can a factor, such as a poison or industrial waste, be studied as in the past. The interactions (toxic concentrations x temperature x salinity x oxygen concentrations, etc.) must be considered together.

Alderdice has found that coho salmon smolts show their greatest resistance to oxidized pulp mill black liquor at one concentration, temperature, and salinity. Resistance could be lowered by a factor of 100 by either raising the temperature, lowering the salinity or reducing the oxygen concentration, indicating the inherent fallacy of setting arbitrary single-level standards for the survival of a species.

Gunter and McKee have shown the complexities involved in a study of just one group of animals and one pollutant--oysters and sulphite liquor. Similar complex relations exist between silt on stream beds and salmonid fish. Times does not permit me to do more than point out the further complexities of a situation where pulp and paper wastes exist to which will be added sawmill, shipping and domestic wastes.

Certain technical programs can be suggested.

1. Find the standard conditions before the deleterious material is introduced, both of the environment and of the animal population.

2. Monitor sea, stream and indicator species. A small continuing study of sessile organisms such as barnacles and invertebrate collections from trawlers.

3. Understand the engineering requirements of industry so that the planning of industrial and civic projects are least likely to result in unsatisfactory conditions. For example, the length of waste lines should receive the same financial and engineering consideration as the length of water mains.

4. The solution of problems is most likely in the design of sewage and waste disposal works, and in the formulation and application of insecticides or in the methods of road construction--not in the setting of levels of contamination.

5. The determination of the active pollutants in wastes is essential.

Fundamental studies must let us know the effects on the animals as completely as possible. They are much less tough than man. Standards for man are not good enough. There is no way around knowing all the answers about the animals if we would have the complete picture.

This material presented was based on the work of Alderdice, Brett, Quayle and Waldichuk. Thank you.

AGRICULTURE

Rolf T. Skrinde*

Water which is applied to agricultural land is subjected not only to a considerable loss in quantity due to evaporation and transpiration, but the return flow is also changed significantly in quality due to leaching and other effects. Ground and surface waters are thus greatly altered in chemical and physical characteristics as they are influenced by irrigation return flows in agricultural areas. It is the purpose of this presentation to discuss some of the effects which agricultural utilization may have upon ground and surface supplies of water, and the research which is needed to reduce pollution to a minimum so as to maintain the water in a satisfactory condition for re-use.

Agriculture is a major water use, whether the application be by natural rainfall or by irrigation. It is estimated that there are nearly 45,000,000 acres of land under irrigation in the United States, 90 per cent of which are in the 17 western states. At an average application rate of more than 3 acre-feet per year, the daily flow of water utilized for irrigation is in the range of 350,000,000,000 gallons. The U. S. Geological Survey evaluated (1) the consumptive use of water for evaporation and transpiration in the Columbia Basin and found an average of 1.75 acre-feet of such loss per acre. Thus, approximately one-third of the water applied for agricultural purposes flows through the soil or runs off to ground or surface supplies, and is designated as return flow.

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Significant changes have been observed in the chemical and physical characteristics of irrigation return flows. In fact, it is highly desirable from the standpoint of agricultural users that some changes do occur. If one-third of the water applied is returned to ground water or streams, it is necessary that this return flow contain three times the salt concentration of the original water in order to prevent undesirable salt build-up in the soil. Maintaining a proper "salt balance" is one of the important aspects of successful irrigation (2). Leaching of natural salts as well as fertilizers and other chemicals applied may result in as much as a five to ten fold increase in concentration of chemicals in return flows.

In addition to concentration and leaching, return water may be greatly altered by physico-chemical reactions occurring in the soil. Ion exchange is one of the most important of such reactions. Fixation or solution of salts in soils due to conditions of dissolved oxygen, pH, temperature, and other effects also may influence the chemical characteristics of return flow.

Although numerous studies have been made of the quality of return irrigation waters, they have been made in almost all cases by those interested in the use of the water for additional irrigation. The quality of water favorable for irrigation is distinctly differently from the quality desirable for domestic and industrial supplies, fisheries, recreation, and other uses. Irrigation water should be relatively high in calcium and magnesium while a soft water low in these elements is preferable for domestic use. Silica, nitrates, and fluorides, likewise, are detrimental in domestic supplies, but they present few problems in irrigation waters. Boron, on the other hand, is of little importance at low concentrations in domestic water supplies, but it is undesirable in irrigation water. An excellent review of present day knowledge concerning quality of irrigation return flows and research needed has been compiled by Eldridge (3) in a publication entitled, "Return Irrigation Water - Characteristics and Effects."

Salinity and Hardness

In order to maintain a desirable salt balance, the total salt output must equal or be greater than the input. Increase in salinity is, therefore, a condition which cannot be avoided in agricultural return flows. Not only is the return flow water from irrigated land usually higher in salt concentration than the water applied, but also a shift in the proportion of the

the various ions present is brought about by the ion exchange capacity of the soil. Water hardness of 300 to 500 mg/l as $CaCO_3$ which is usually considered to necessitate water softening in the home, is not uncommon in irrigation return flows.

Continued studies on salinity and hardness of return flows are needed to provide information regarding ion exchange and leaching characteristics of soils. This will enable the prediction of future quality of return irrigation water and its effect on water re-use. Although soils are known to be cation exchanges, little is known of the effects of soils on the anion content of waters.

Temperature

Several valuable studies have been made on the effect of agricultural water use on temperature of return flows. Thermograph readings proceeding downstream on the Yakima River have shown increases of from 5° to 10°C in temperature, which have been attributed to irrigation return flows (4).

Higher temperatures emphasize tastes and odors in water, inhibit various types of fish while stimulating others, and accelerate the growth of biological life, such as that producing nitrification in soils. The relationship of agricultural utilization of water to temperature changes, and particularly the significance of such changes on the entire chain of biota inhabiting water is an area requiring considerable study. Increasing attention is being given to the relatively new problem known as thermal pollution.

Turbidity and Color

Silt pollution is nearly always detrimental to the beneficical use of water for such purposes as domestic consumption, fish and wildlife propagation, and recreation. Turbidity renders the water undesirable for domestic use at a concentration of 10 units. Some studies, such as that on the Potomac River Basin (5), have shown silt to be one of the major pollutants of a river.

Turbidity is caused by sheet and gulley erosion of farm land, coupled with rapid surface run-off. The quality of such surface run-off is usually seasonal in nature, and streams may be adversely affected for only a few months of the year. Studies are needed to determine more satisfactory methods of applying water in some areas in order to reduce surface run-off. Improved methods of lining ditches and canals should also be sought, as well as general soil conservation methods. Inauguration of proper conservation methods have reduced erosion by 30 to 75% in areas of high silt pollution (6).

Increased color in return flows from irrigated areas have been attributed primarily to irrigation. Studies are required to determine with greater accuracy the cause and significance of color in such flows.

Nutrients

Agricultural return flows often contain significant amounts of nitrogen, phosphorous, and potassium. Potassium is usually present in natural waters and nitrogen may be fixed in the soil by plants such as the legumes. Phosphorous is retained to a substantial degree in the soil, however, and is therefore at times not found in return flows.

Sawyer (7) indicates that 0.01 PPM in inorganic phosphorous may cause excessive plant growths in water. The presence or absence of phosphorous, therefore, often determines the extent of algae and weed growths in surface waters.

There are differences of opinion among investigators regarding the contribution of irrigation return flows to the nitrogen and phosphorous content of ground and surface water supplies. Some studies indicate that a considerable portion of the fertilizers added to soil are being leached out by the drainage water. There can be little doubt that fertilizers used on agricultural lands provide some of the nutrients found in return flows. Certain results have indicated, however, that at least a portion of the nutrients have originated in deeper soil strata and are not related to fertilizer application. Studies are needed in which the nutrients supplied by fertilizers can be distinguished from those indigenous to the soil. Studies are required in addition to determine the concentrations of chemicals such as nitrates present in rainwater. Trace quantitites of nitrates, chlorides, and possibly other such contaminants of rainwater could, over years of concentration by evaporation in soil, provide a considerable build-up of these chemicals.

Conditions affecting the formation and movement through soil of nitrates and phosphates require careful study. Effects of oxygen tension, temperature, pH alkalinity and other factors on nitrification are not completely known. Nitrates as high as 100 Mg/l have been found in a few wells in Eastern Washington while 10 Mg/l may cause fatal methemoglobinemia in children. The entire picture of phosphate movement through soil, and the effects of such factors as pH and dissolved salts is little known and requires study.

Tastes and Odors

Decomposition of organic materials in soil often causes tastes and odors in return flows, which are difficult and costly to remove. Isolation of the taste and odor producing compounds is a much needed area of research in agricultural water utilization. If these compounds were known, their parent organic products could be identified and steps could be taken to prevent their growth. Such studies would also have great application to other areas of water pollution.

Sanitary Quality

Bacterial contamination in streams carrying return irrigation water is caused by discharge of sewer outfalls, rural septic tanks and cesspools, and flushing of animal manure. Extensive studies have been carried out of bacterial travel through soil, with the greatest amount of work performed at the University of California (8). From these studies it was demonstrated that coliform organisms decreased rapidly with soil depth, and at the 4 to 7 foot level the coliform count dropped below 1 per 100 ml. The most distant point of lateral movement of coliforms was 100 ft. Data indicate that under most conditions return irrigation water does not cause the public health problem of bacterial contamination of ground water supplies.

Flushing of animal manure, garbage, and other debris into surface water sources through drainage ditches constitutes a potential contamination problem, however, and should be further intestigated. Studies made in the Yakima Valley (9) indicated that natural die-away reduced coliforms by more than 80% over a 20 mile canal system.

Pesticides

The question of whether insecticides, herbicides, fungicides, and other related economic poisons used for agricultural purposes ultimately enter water supplies to constitute health hazards and otherwise cause damage has not been fully evaluated. There is considerable evidence that these chemicals applied to plants and soil have entered streams and caused extensive fish kills (10). Although pesticides are utilized in nearly all homes in small amounts, their use in agriculture for routine control of weeds and insects results in such large scale applications that water pollution is a definite possibility.

The total production of pesticides in the United States is approaching one billion pounds or pure compounds per year, which is consumed in the form of approximately 1.5 million tons of commercial preparation. Prior to 1940, most pesticides were inorganic in nature, but over the past ten years the ratio of organic to inorganic toxicants has increased annually. The present United States production of pesticides is expected to double by 1970, at which time synthetic organic compounds may make up as much as 90 per cent of the market.

There are presently some 200 pesticide compounds being formulated into more than 7,000 commercial products as listed in the Pesticides Handbook (11). New compounds are being produced at a rapid rate, and new uses are being found for products already in existence. Little is known of the ultimate fate of pesticides which have been used for several years, and the development of new chemicals serves to increase the problem. The chlorinated hydrocarbons are especially resistant to degradation to non-toxic end products, and may persist for months or years following application.

There is no direct evidence that pesticides enter waterways by way of return irrigation flows. The problem as it relates to irrigation has not been investigated, however, although it would appear probable that many of the applied chemicals may be washed into drainage ditches by surface flooding or may enter ground water by percolation through the soil. At Washington State University a number of carbon filters are being installed to extract pesticide residues from irrigation return flows in surface and ground waters in the Columbia Basin. Identification of the residues will be accomplished by infra-red and chromatographic techniques. It is believed that the information obtained will aid in determination of the extent of degradation of pesticides in soil, their degree of retention by soil, and the public health significance, if any, of the residues in irrigation return flow.

One of the major needs in the field of pesticide chemistry is a simple method of identification of trace quantities of these toxic compounds in water supplies. Bio-assay techniques have been advocated by some investigators. Studies are being conducted at Washington State University on the detection of synthetic organic pesticides, and methods of removing and concentrating pesticides from water are being evaluated. Paper chromatography is being used to detect and quantitatively estimate residues extracted from water samples. This method will be field tested in 1961, and studies will be carried out to improve gas chromatographic technique.

Although chlorinated hydrocarbons are generally more stable than organic phosphorous compounds, little is known about the biochemical or chemical degradation of many of the preparations in soil and water. Studies are being carried out at the University of Washington on the biochemical degradation of these chemicals. A great deal of research work is needed in this area.

The effects of DDT and some of the other more popular synthetic organic pesticides on man have been studied quite extensively. Much more research is needed on the long term effects of small quantitites of these compounds, however, before their complete acceptance for extensive use without ill effects on the public health.

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INDUSTRY

Herman Amberg*

The problems involved in industrial water quality are many and quite diversified. Different industries produce different wastes and the characteristics of the receiving waters vary substantially depending upon hydrology, waste load, assimilative capacity, usage and regulatory control. Even if we narrow the field to one industry, i.e., pulp and paper, these same problems will in general be applicable.

The accomplishments of industry and specifically the pulp and paper industry's pollution abatement activities can be measured by several criteria: reduction in total waste load; reduction in pollution load per ton of product; conservation of fiber or other new materials; and conservation of water.

We are constantly being exposed to statistics and statistical projections. These are the projected water usage figures and pollution loads of 15 years ago into the future, i.e. 1970 to 1990. These figures naturally are alarming and in many cases misleading since they do not take into consideration improvements which are constantly underway. For example, in reducing pollution and water usage, most industry has made notable, in fact, phenomenal, progress during the last 15 to 20 years. I would like to cite the pulp and paper industry again as an example.

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In the years between 1943 and 1959, annual production of pulp and paperboard increased from 17 to 34 million tons, an increase of 100%. The total waste load, on the other hand, was reduced by approximately 2%. To put it another way, the waste load from the average ton of paper and paperboard has been reduced by 51% since 1943. During this same period, the industry reduced its average fiber loss from 5% to less than 2%, a saving of over a million tons of fiber and a vast reduction in the waste load. This saving represents over one and a half million cords of pulpwood.

The reduction in the pollutional effect of industrial wastes has been accomplished by a number of different ways and most of the methods now in use are based upon research accomplishments over the last twenty years. These include effluent treatment, new and novel waste disposal procedures, reduction of solids losses by recirculation of process waters and use of solids removal equipment, retention of increased percentages of wood substance in the finished product, more efficient recovery of chemicals and heat from spent pulping liquors, new recovery systems applicable to certain pulping liquors and recovery of valuable by-products.

Vast economy in water use has also been accomplished during this period. Today when great concern is being expressed in connection with future water resources, the pulp and paper industry can look back with satisfaction on an average reduction in water use of over 50% per ton of production during the past 16 years.

The pulp and paper industry has spent tremendous sums of money on research aimed specifically at pollution abatement. Methods presently being used as I have stated, are based upon the findings of industry-sponsored research conducted over the past twenty years. Research is presently being intensified to solve some of the more pressing and persistent problems.

One of the problems that has plagued our industry for many years is the sulfite waste liquor problem. Here we are not dealing with a waste treatment problem but what we should refer to as a waste utilization problem. The industry is not particularly pleased with the fact that about 50% of the tree is being wasted and primary emphasis is being placed on finding uses for this material. The sulfite waste liquor problem has also been plagued by economic difficulties. Although many uses have been found, the market potential of many of these products has been limited or the product cannot be economically produced on the West Coast to compete with the East Coast markets. However, the market potential for many of these by-products on the West Coast is changing and we may expect that the economics of by-product recovery will improve as the marketing potential of this area increases. Large scale uses are being found for the wood sugars and lignin, and there are a number of possible break throughs on the scientific frontier which could eliminate this problem within the next five to ten years. In the interim period stop-gap solutions must be used to full advantage. I might add that this type of industry-oriented research can best be done by the industry and we feel that we have done a good job in this phase of our industrial research.

One important phase of research and development is cost reduction whether it be on the main line of products or industrial waste treatment. Often this is overlooked in dealing with the industrial waste problems; particularly if there appears to be some urgency. The tendency often has been to lift processes from the sanitary field and attempt to apply them to industrial wastes with the hope of by-passing expensive and time-consuming research. These attempts may be justified in some cases but they cannot help but be extremely costly and may even be utter failures. With the competitive nature of industry in the future, some research effort should be channeled into treatment cost reduction studies. In this respect, by-products will be important in the future in defraying at least a portion of the waste treatment costs.

Fundamental work on receiving waters and industrial wastes is one phase of research which is starting to receive some attention. I recently had the privilege to visit the Oregon State College Laboratories of the Fish and Game Department and USPHS to view some of the work underway. I was impressed by the caliber and scope of the research projects and to to my knowledge these are the first fundamental long range studies ever conducted on some of our more pressing stream problems. Of particular interest to industry and regulatory agencies are the dissolved oxygen and the natural stream studies. The experiments have been so designed to study the effects of pollution upon the ecological balance and also to study the effect of natural variables upon the stream ecology.

This type of research is not too popular with many because of the time involved. However, this is the only way to obtain some of the fundamental information required for a rational approach to the solution of some of our water quality problems. The Oregon State College and USPHS researchers are to be commended on tackling some very difficult and long range problems. I might add that this type of long range fundamental research can best be conducted at our Colleges and Universities where a wide variety of disciplines can be brought to bear on problems. If we are to keep pace with our expanding economy, our fundamental research efforts must be increased accordingly.

I feel rather confident that the industrial research presently underway supplemented by fundamental studies such as those being conducted at Oregon State College, University of Washington, Washington State College and other institutions will be able to solve the variety of waste problems that will confront industry in the next decade.

POLLUTION CONTROL

James Behlke*

Research needs of a Pollution Control Agency are extremely wide in scope and touch in part or totally encompass many disciplines. It is quite obvious that in this short presentation only a few subjects can be mentioned. Therefore, I will endeavor to present some ideas on the broad areas of research needed and a limited number of specific research items.

During the National Conference on Water Pollution held in Washington D.C. in December areas of research needs were indicated by numerous workers in the field. I would like to indicate in part some of their thoughts. Hollis (1) indicated that a substantial program of research is needed:

1. To develop practical methods for measuring and for removing dissolved pollutants--for application where wastes have serious toxic potentials.

2. To develop practical supplemental treatment methods to stabilize further the effluents from conventional treatment. This is for application in those areas where stream use justifies almost completely stabilized organic discharges.

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Pearson (2) stated that of the numerous critical research needs, the following appear to be of major importance:

1. Development of adequate methodology for quantitative, physical, chemical, and biological effects of waste discharge upon receiving waters and sediments.

2. Definition of the toxic agent concentration, time of exposure functions for common and significant organisms and agents to permit more realistic estimates of the so-called "safe concentrations" of wastes in the environment.

Boruff (3) indicated that needed research projects awaiting attention, include:

1. Definition of the toxicity and persistence in streams of certain new chemicals.

2. Determination of the dangers from widespread use of the newer agricultural chemicals.

3. Development of more efficient waste treatment methods so as to reduce construction and operating costs.

Eliassen (4) recommended that:

1. Research be performed on the behavior and fate of modern organic contaminants in the water environment.

2. Research be initiated to develop more effective means of removing pollutants from water in municipal and industrial water treatment plants.

3. More effective process controls of industrial waste discharges be developed.

4. The recovery or utilization of industrial process wastes be given greater consideration as a means of preservation of water resources.

5. More sophisticated industrial waste treatment processes be developed through research in order to prevent excessive stream contamination from complex organic substances and inorganic salts which can neither be recovered nor utilized.

Hazen (5) indicated that research in the treatment of municipal wastes should be directed along the following lines:

1. To search for catalysts--chemical, physical and biological, that will speed up the natural processes now used and permit construction of much smaller tanks and equipment.

2. To explore thoroughly the possibilities of chemical treatment, or chemical and biological treatment using new chemicals and new strains of bacteria.

Fair (6) in summarizing the subcommittee report for panel IV of the conference indicated the flow of research findings on the water environment must be increased and intensified in depth as well as breadth.

Fundamental research is needed in many aspects of water pollution control including determination of the limits to which receiving bodies of water and biological as well as other treatment units can be safely loaded for the disposal of increasingly complex waste materials and studies of long-range chronic effects of trace contaminants in water.

Fair further indicates the need to increase research effort on the behavior and fate of newly introduced organic contaminants; to develop more effective means of removing pollutants from water in municipal and industrial water treatment plants; more effective process controls of industrial waste discharges; better recovery or utilization of industrial process wastes; and more sophisticated industrial waste treatment processes.

Water supply and pollution trends show that one of the most pressing problems in water quality management is the development of new treatment processes that will remove more of the contamination from municipal waste waters than present methods are able to do.

These presentations have indicated three broad areas of research. The first being the ever increasing need for information regarding the environment. The environmental problem should be approached by determining the existing biological, chemical, and physical characteristics of fresh, marine, estuarine and ground waters. It may appear that such information can be logically obtained by the regulatory agencies through the developing of a massive basic data program. But there exists many pitfalls to this approach such as the development of basic sampling networks, the development and further refinement of analytical procedures particularly in marine and estuarial areas, more effective methods of determining mass movements of bodies of marine and ground waters, development of indices and parameters for biological studies. With such a program considerable data would be accumulated, necessitating some type of machine programming and processing so that the information can be evaluated. It is evident that many specific research projects can be developed from the broad area of determining the existing chemical, biological and physical characteristics of the total environment.

An example of the work that could be done in Washington is an evaluation of Puget Sound as to the present status of the environment. Is the Sound chemically, biologically and physically fairly well in balance? If not, what is the rate of decay? Should we be seriously concerned with the mass quality of this body of water now? Are there subtle changes taking place in the water quality that are not apparent? Can we expect to have a similar problem in the Sound that exists in Lake Washington and in some marine areas of the Scandinavian Countries?

The second area of research appears to be the need for complete evaluation of the effect on water quality of the wide range of chemicals and chemical wastes, with particular emphasis placed on the newer organic chemicals, chemical sprays such as insecticides and weedicides and some of the complex chemicals that have been with us many years. Much work needs to be done in determining improved analytical procedures, rates of decomposition, toxicities--acute and chronic, and resistance to treatment. These are a few of the obvious areas of study.

Specific examples of research needed is further work on a relatively new chemical. A.B.S. (alkyl benzene sulfonates) and an old standby, sulfite waste liquor. In regard to A.B.S. better analytical procedures need to be developed for determination of minute concentrations, also, further work on toxicities and the degrading by conventional treatment and in nature. Gunter & McKee (7) indicated in their recommendation to the Pollution Control Commission additional research efforts on sulfite waste liquor.

1. To measure quantitatively the effects of sulfite waste liquor on the estuarine environment and especially on the nannoplankton on which oysters and their larvae feed.

2. To determine the toxicity of specific components of hot-blown SWL, especially the low-molecular-weight organics that decompose on stabilization, and

3. To investigate the biochemical degradation of sulfite waste liquor and its various components.

Sulfite waste liquor is mentioned to point out one chemical waste that has received much attention for years by researchers but yet much additional work is needed.

The third area of broad research needed is expansion of work on water and waste treatment processes, industrial waste recovery and re-utilization of waste waters. In this area there are many research projects that can be pursued such as determining if biotas can be acclimated for treatment of organics electrolitic removal of nutrients, high frequency oxidation, and application of the petro-chemical industries technology to waste treatment.

An example of a specific problem in this area is: Can formaldehyde and menthanol be aerobically decomposed in a sewage stabilization pond? What is the acclimation period? Will odors prevail during the acclimation period? What percent reduction can be anticipated? Will climatic changes appreciably affect removals? What is the maximum loading per acre that can be applied?

It can be seen that this one problem can cause many questions that can be logically answered through research.

In conclusion I would like to point out that before work in these three broad areas of environment, chemical and treatment is further advanced, there is a tremendous need for complete documentation, accumulation, evaluation and summarization of the existing research and data in a readily available form so that we may truly know our present status. Mr. Eldridge's recent efforts to activate a program of complete cataloging of pollution control references is the first positive step toward this end.

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LABORATORY

Fred J. Burgess*

The population explosion, increased industrialization and dwindling water supply have emphasized the necessity of controlling pollution and eliminating it where possible. This problem has gained national recognition and has stimulated much research, development and survey-evaluation work. It is, therefore, appropriate to ask if our "tools" are good enough and "sharp enough" to do the job ahead. Certainly the engineer and scientist engaged in water pollution control work will be the first to admit that the "BOD" bottle, the burette with its 1/40 normal $Na_2S_2O_3$ and his "bible" of standard methods are venerable old fighting weapons but woefully inadequate for the highly complex problems we face.

What then are the necessary additions we must make to our arsenal for the pollution control fight. Flexibility, imagination, intelligent and considered judgment and a generous supply of "pep" pills are generally considered as first-line weapons.

The list of analytical methods needed is long and varied. In all cases simplicity of making highly complex micro-chemical and biological measurements and interpreting them is needed.

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The BOD test is a good example of needed improvement. Without complete evaluation of reaction constants, long term BOD, immediate BOD, and a standardized bacterial population, the test is of small value. Yet, because of its simplicity of understanding and elegance of mathematical derivation, it has become near and dear to every engineer's heart. The five day-20°C BOD, are taken as "gospel truths," even though for samples containing the same total decomposible organic material reaction constants may vary as much as three to four fold. Chemical oxygen demand and other oxidation tests to determine the "oxygen depletion" characteristics of waste also have shortcomings. An accurate, simple and accepted test to measure this type of pollution potential is badly needed.

The test for tannins and lignins which actually measures many hydroxylated aromatic compounds also needs careful consideration. Certainly the biological half-life of wood sugars, toxic elements, and other compounds associated with the waste from the wood products industry is different from the half-life of lignin and tannin-like matter. Accepting their presence as being indicative of the concentration of total plant effluent is questionable. It is always easy to shoot holes in the other fellow's target and certainly all analytical tests have their shortcomings.

With the prospect of considerable reuse of water and the need to develop tertiary treatment methods, identification of waste residuals of biologically hard compounds is extremely important. The carbon-filter technique is a promising development in this field. Hydro-carbon recovery by this unit is good, but carbohydrate-like compound recovery is relatively inefficient. The methods of extraction and exact identification of material by chromatographic and spectrometric methods are complex and expensive and beyond the scope of most laboratories.

Perfection and simplification of these tools are necessary. Efficient and economical methods of continuous sampling are a major need in the pollution control field. The cost of analysis and the consequences of enforcement based on improper interpretation make good sampling a primary necessity. Yet, how many reports have been based on the analysis of two grab samples and a straight line plot of data?

Excellent analytical tools for evaluation of data are becoming available in electronic computers. It remains for engineers and scientists to program the collection of data to obtain the needed answers.

Development of micro-biological methods is another area of need. Interpretation of coliform densities in terms of health hazards and the evaluation of disinfection needs, when the problems of coliforms of non-fecal origin or bacterial re-growth are considered, is difficult using present methods. Methods for using fecal streptococci or the entrococcus groups as positive indicators of contamination are being developed by the United States Public Health Service at the Robert A. Taft Sanitary Engineering Center. These methods appear very promising.

In the field of fisheries, analytical methods for measuring long-term, low-level, chronic toxicity problems are not available. Acute bioassays and bio-indices have been used to advantage but these tell little of the chronic toxicity problem.

Engineering tools are also needed for evaluation of treatment processes. Rule of thumb approaches to many treatment processes are the result of being unable to measure process variability. The biological contact processes are a prime example of this problem.

The cost of analysis of the rather complicated tools available has been a deterent to much research and development. An engineering failure that should mark high in this decade has been the unwillingness to recognize and adequately provide for analytical procedures.

Support for specific research and development of analytical methods is available from federal and industrial sources. The development of these methods must proceed largely at universities and colleges. Here is located the largest reservoir of competent scientists.

PROBLEMS AND RESEARCH IN THE FIELD OF ENVIRONMENTAL HEALTH

P. H. McGauhey*

There is ample evidence that the problems of water quality pre-date man's records of his contests with his perverse gods. Certainly by 330 B.C., when Rome finally sent its engineers afield to bring in a supply of pure water, the quest for quality was already an ancient hydrologic pastime. We can, therefore, but marvel at the persistent streak in man's nature that enables him after more than 2000 years to continue his attack on prehistoric problems with the vigor evident in this morning's program. Perhaps it is because almost overnight"water quality" has become a glamour phrase. Perhaps not. In any event, competition for a relatively fixed water supply by various elements of our growing urban-industrial-agricultural society is now a matter of concern of such magnitude that water quality legislation is being pressed by the Congress of the United States, and even petrified public agencies are beginning to stir with dreams of empire in water quality research and management.

Out of a seemingly endless concern for water there emerged, some thirty years ago, the profession of sanitary engineering, dedicated at first primarily to problems of water quality control.

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Yet the profession was scarcely in its teens when relentless nature added a new train of environmental health problems. And what is worse, these added problems tended to undo much of the gain the sanitary engineer had made in the fieldoof water utilization, rendering inadequate those solutions which for a season showed prospect of being satisfactory. My discussion today concerns the scope of this newer complex of environmental problems--air resources, radiological health, industrial hygiene, environmental sanitation, and resources management. And if time permits, I may dwell briefly upon some of the new micro-factors in water quality, the prospect of ground water contamination, the need for tertiary treatment of wastes, the problem of urban and agricultural refuse disposal, and the problems of water reclamation.

In each of these several areas, research is being directed to special technical problems so diverse as to suggest an intellectual Tower of Babel. And so it might become were it not for simultaneous efforts to conceive systems for relating and managing all elements of environmental health--integrated systems of land-water-air resources planning and use, of soil-water-crop management, and of economic apportionment of water among competing beneficial uses.

On the theorum made famous by James Thurber that "It is better to ask some questions than to know all the answers," I shall begin this afternoon's discussion by identifying some of the problems in environmental health concerning which research is, to my knowledge, in progress, noting as time permits some of the interesting details of this research. Unfortunately, it will not represent a balanced picture of the research effort throughout the country for of necessity I shall deal primarily with the work of my own group at the University of California.

Water Resources

You have already heard, or read in the reports of the Senate Select Committee, of a widespread recognition that a minimum stream flow of important magnitude will be required merely to transport our waterborne wastes to the ocean. At the same time, those representing recreation and wild life culture envision a minimum flow of "pure" water to support their interests. Obviously the two do not speak of the same "minimum" flow. In another case, the Bureau of Reclamation is going ahead with plans to irrigate a western state in support of an agrarian economy which would require a reduction of the state's present population by some 20,000 persons. At the same time, the State Chamber of Commerce is busily planning for an urban-industrial economy involving twice the present population of the state. Again, political considerations favor the constructing of an aqueduct to deliver publicly subsidized water to an agricultural area which is giving way to subdivisions so rapidly that none will occupy more than a 50' x 120' lot by the time the aqueduct is completed. Everywhere, owners of water rights are suddenly finding that "acre-feet" no longer describes water; quality has become its fourth dimension. More than 2000 new industrial products produce wastes of unknown significance, urban dwellers increase their water usage, and agricultural drainage waters in the west add an increasing burden of salinity.

Here is an array of problems that thus far have defied IBM, confounded outmoded political and economic assumptions, and challenged the ability of engineers and others to devise comprehensible systems, both of analysis and synthesis. Here is an area in which many disciplines seek a future empire through research; an area in which political scientists, economists, social scientists, engineers, planners, and politicians vie to pre-empt; a sea of trouble on which the broadly educated humanists float like scum and in which the deeply indoctrinated engineers and scientists sink like sludge to the bottom--both equally unable to pervade the entire mass. This is the area of resources management, systems analysis, interdisciplinary team research, operations research, or what you will: the offspring of earlier problems of water quality which survived all our considerable advances from disinfection to activated sludge. I purposely leave fittingly obscure the nature of the research directed in this area both because the problems are complex, the approach obscure, and the subject already considered in some detail in the preceding session. Furthermore, it is my main purpose to deal with some other aspects of environmental health, concerning which I will try to be more specific.

Atmospheric Pollution Control

From the days of alchemy almost until the space age, we got along with quite gross analyses of the atmosphere around us. Oxygen, nitrogen, and carbon dioxide were observed and their relative percentages duly noted. Refined observations yielded evidence of the presence of crypton, xenon, argon, helium, ozone, and the like--largely matters of curiosity. Fog, dust, and haze were recognized as natural nuisances at times, and eventually smoke from burning soft coal all but made cities like Pittsburg, St. Louis, and Detroit unbearably dirty. Only in indoor industrial environments were other particulates and gases given serious attention by public health organizations. Then, as population densitites increased, we began to hear of smog--a big national joke because it was unique to Los Angeles. But our laughter was short-lived--disasters from polluted air such as occurred in London, Donara, and the Meuse Valley were in the making. The upshot was that some 10 years ago we found ourselves with a full-blown problem of environmental health arising from the micro-pollutants of air about which we knew next to nothing, and from physical and chemical interactions of which we were equally unaware.

Thus the problems of air pollution caught us in a state of almost primitive ignorance which could not be overcome by the mere enactment of legislation authorizing the setting of standards and the establishment of Boards, however prominent their legal teeth. The list of specific problems included:

1. Development of methods for detecting and isolating micro-constituents of polluted atmosphere.
2. Applying new methods to the identification and monitoring of individual air pollutants.
3. Development of methods for reducing or preventing production of various air pollutants at the source.
4. Determining the effect of various pollutants on the public health and establishing permissible limits of human exposure to individual pollutants and to combinations of pollutants.

5. Determining the tolerance limit of vegetation and crops for various air pollutants.
6. Establishing realistic standards for air pollution control purposes.

Research in each of these several problem areas is in progress and in varying stages of completion. At the Sanitary Engineering Research Laboratory of the University of California, projects supported by the Public Health Service have been directed primarily to the first two problem areas. Using such techniques as chromatography, spectroscopy, fractional distillation, and fluorescence, more than 60 synthesized aromatic unsaturated hydrocarbons have been isolated from the products of inefficient combustion of gaseous and liquid fuels. Three of these are known to be carcinogenic to animals, and are presumed to be so to humans as well. Some 35 oxidized compounds--the real tear-jerkers--have likewise been isolated and are currently being studied for molecular structure and identification. The growth of giant bacterial cells in the presence of carcinogenic hydrocarbons has been observed and research is well under way to determine the nature of the resulting cell changes and to explore the possibility of using the phenomenon in the bio-assay of atmospheres for the presence of carcinogenic fractions.

Investigative work on the detection and measurement of sulfur oxides in industrial stack discharges and on the nature of their observed damage to vegetation has likewise been undertaken and reported.

Radiological Health

As an environmental health problem, radioisotopes present a unique situation in at least two major aspects. First, is the very real necessity for a method of radioactive waste disposal before the wastes are created. Unlike industrial and domestic wastes with which we have contended for water quality for 150 years in a slowly losing battle, radioisotopes cannot simply be discharged to the environment and ignored while sanitary engineers and others seek ways of re-establishing the damaged environment. The second difference is that the control of nuclear fission technology rests within the Federal Government where national necessity dictates that production of radioactive wastes must not await the answers to problems of waste disposal. Hence, wastes of necessity have artifically and uneconomically been stored or dumped in the ocean, creating the false impression in outsiders that peaceful use of the atom may proceed without answers to environmental health problems.

Problems of radioactivity in the human environment are too numerous to catalog here. An incomplete list of those of particular interest to sanitary engineers include:

1. Educating people concerning the true nature of the hazards of radioactivity in the human environment.

2. Off-setting realistically the clamor of peoples with underpowered economies for the genie of nuclear power; as well as the engineers and entrepreneurs who seek immediate installation of plants with the same blind unconcern for waste disposal that has characterized the fossil fuel era of industrial-urban economic development.

3. Developing economical and practical methods of disposal of radioactive wastes which may find their way into the general environment through medical, industrial and research uses of isotopes.

4. Devising methods of applying radioisotopes to the solution of problems throughout the whole gamut of environmental health.

5. Perfecting methods of decontaminating the environment especially man's air, water, and food contacts, following an accident or hostile release of radioactivity.

6. Determining the effects of irridation on men, animals, and plants, and the establishing of realistic limits of permissible exposure.

Research on the environmental health aspects of radioisotopes conducted by the Sanitary Engineering Research Laboratory of the University of California is concerned principally with the problem areas 3, 4, and 5. Projects in progress or reported within the past ten years have been concerned with the uptake of radioisotopes by activated sludge and by various dissolved solids in natural waters; with ground disposal of radioactive wastes; with the removal of radioisotopes from contaminated water or waste effluents by natural soils or synthetic ion exchange resins; with the disposal of wastes from large test animals fed with isotopes of strontium; with the development of methods for detecting tritium; and with the application of tritium and other radioisotopes to the tracing of ground water movement. In addition, detergents are being traced through sewage treatment processes and in surface and ground waters by radioactive sulfur; sediments in San Francisco Bay have been followed with radioactive gold; an evaluation of fall-out problems in the human environment has been completed; and practical methods of decontaminating water supplies are under investigation.

Septic Tank Percolation Fields

Since World War II, the use of septic tanks has ill-advisedly been permitted in vast urban housing developments where their behavior eventually came to the attention of a single agency, the Federal Housing Administration, through its mortgage insurance program. Thus an extremely serious problem of failure of septic tank percolation fields within 1 to 5 years was brought to light.

An FHA-sponsored survey conducted by the Public Health Service soon revealed that surprisingly little is known about the design and behavior of sewage-loaded soils.

Under FHA sponsorship, the Sanitary Engineering Research Laboratory has made considerable progress in determining the conditions under which soils will clog and the mechanism of that clogging. Current research is therefore directed toward the development of design principles which will minimize the observed clogging phenomena and thus aid in establishing realistic design criteria.

Detergents

The rise of the household use of synthetic detergents since 1930 has created a somewhat unique environmental problem--unique in that detergents do not in themselves constitute a demonstrated health hazard, but may interfere with the functioning of systems created in the interest of the public health or delay environmental health proposals by the mere presumption that detergents may be a factor. The first problem of detergents in the environment, then has been "What is the problem of detergents?"

A considerable body of research has been directed to this question and it is agreed for the present that in the United States we cannot presently condemn the use of synthetic detergents on the grounds of public health menace or danger of destruction of the effectiveness of waste treatment processes. This does not mean that they do not present problems. In fact, there is a growing uneasiness that when the micro-constituents of water present a hazard analogous to that experienced in air pollution, detergents may in some way be among the offenders.

Recent research by the Sanitary Engineering Research Laboratory and others under the sponsorship of the Association of American Soap and Glycerin Producers has pretty well established the extent to which ABS is destroyed during sewage treatment, and has suggested methods for its partial removal. However, investigation is warranted into matters as:

1. Prevention of frothing of surface waters receiving sewage treatment plant effluents, and the conditions under which such frothing occurs.
2. The significance of any given concentration of detergent in a surface water in relation to any or all of a number of beneficial uses of the water.
3. A rationale on which to base a standard for detergents in stream pollution control.

4. The behavior of detergents underground and the possibility of long-term injury to ground waters recharged with detergent-bearing effluents.
5. Methods for economical detergent removal from waste waters should such removal become an objective of waste treatment.

Current research at the University of California, sponsored by the Public Health Service, is directed to the last of these two problems. Detergent removal has been shown to be feasible down to 1 ppm. Whether this or a greater degree of removal is either feasible or necessary in the interests of environmental health or control is a part of the unsolved aspects of the detergent problem.

Underground Travel of Pollution

The possibility of water reclamation by ground water recharge through surface spreading or direct injection of flood or waste treatment plant effluents has long intrigued engineers and lay citizens interested in water conservation. The current research on tracing of ground water movement previously mentioned provides a new tool for checking the environmental safety of present and proposed recharge projects. Extensive research by the Sanitary Engineering Research Laboratory reported in previous years attested to the public health safety of recharge as far as bacterial travel is concerned. Current Sanitary Engineering Research Laboratory projects on septic tank percolation fields and on the behavior of detergents underground may further clarify the problem of ground water reclamation. The same is true of numerous other studies throughout the United States. Unanswered questions to which research is presently being directed or is in prospect include:

1. The significance of insecticides, herbicides, and other heavy organic molecules in irrigation drainage waters and in reclaimed water.
2. Methods of detecting small quantities of toxic substances, as well as processes for removing them from waste waters.
3. The underground behavior of many individual inorganic and organic wastes from the production and use of newer industrial processes.

Biological Control of Human Environment

A wide range of problems of environmental control seem susceptible to solution in many geographic latitudes by an approach which I may designate generally as "Biological Engineering." In one of its aspects most pertinent to sanitary engineering, it involves the reclamation of both water and organic matter in human sewage and other organic wastes by the conversion of the organic fraction of wastes into high-protein algal cells suitable for an animal feed supplement or, in some areas, as a human foodstuff. During current and past experiments extending back to 1950, the Sanitary Engineering Research Laboratory of the University of California has:

1. Established the conditions under which sewage-grown algae flourish.
2. Investigated the techniques and economics of algal harvesting from waste treatment ponds.
3. Demonstrated the water reclamation and organic reclamation potential of algal culture in sewage and organic industrial wastes.
4. Initiated experiments on the application of the process to the disposal of animal manures.
5. Developed a closed ecological system for biological control of enclosed environments such as might pertain in long-time space travel.
6. Supported experiments in the nutritional value of sewage-grown algae.
7. Isolated algal strains particularly suited to high temperatures and to certain organic wastes.

The range of problems to which biological systems may be applied in environmental health is by no means yet defined. Research in this direction is proving to be one of the most fruitful approaches to problems of environmental sanitation, from which a whole host of side benefits may accrue.

Solid Refuse

The ancient Roman signpost which warned "Take your refuse further or you will be fined," gave recognition to an environmental problem, but at the same time suggested a solution. After 1500 years of progress we now have the problem minus the solution. As Frank Stead of the California State Health Department said a few years ago, "Burn it, and the air pollution people get after you. Bury it, and the water pollution control board is fearful of ground water pollution. Feed garbage to hogs, and people revolt against the hog farm." Thus we may recognize that the problems of solid refuse disposal are as yet imperfectly solved. In fact, they have worsened through recognition of air pollution problems and through the activities of control agencies prepared to ask more questions than they are prepared to answer. In areas subject to smog control, for instance, we are accused of all but outlawing fire. Household rubbish burners are banned; municipal incinerators are suspect;

freeway right-of-way clearing or urban renewal projects are forbidden to burn debris; and in some cases, farmers are being urged to run all organic debris through shredders or choppers and mulch it into the soil. So is created a round-robin of problems. The city incinerator creates an air pollution problem, the air pollution authorities toss the problem back considerably magnified. The orchardist creates an air pollution problem. He is urged to take measures which will establish an incubator of disease and insects under each tree. He must then use more and stronger insecticides, which creates problems of removal for the canner, who if successful in his efforts, transfers the problem to the water quality control people in the form of the micro-quality factors which they, in turn, struggle to overcome.

Research directed to this complex of problems has, at the University of California, been concerned with sanitary landfill, incineration, and composting as economical methods of refuse disposal and reclamation. In addition, other work has been done on the control of flies and the fate of bacteria during municipal refuse disposal as well as on the nature of leachings from landfills and dumps.

Current research on solid refuse disposal is widely dispersed throughout problems which result in related areas from refuse disposal practice. Direct studies, however, are in progress on the suburban and rural wastes from animals--a subject worthy of special discussion.

Disposal of Animal Manures

Of all environmental problems confronting our urban-industrial society, the least understood and appreciated is that of animal manures and the attendant fly problem. To the average pseudo-sophisticated city dweller, cows and chickens are the handmaidens of slightly laughable yokels, or the source of wealth of the minority of Texans who do not own oil wells. Consequently, when they purchase a cardboard house from some subdivider bent on turning a quick profit by bull-dozing the flood plain next to a dairy, a beef fattening installation, or a chicken ranch, they bleat piteously to the health authorities when fly season rolls around. In cases where the animal feeder has been in business for 20 years and has invested several millions of dollars in his installation there develops an understandable inclination to "stand in the way of progress."

Few recognize the magnitude of the animal manure disposal problem. In California, for example, there is some 80 million cubic yards of animal manure produced each year in stock feeding pens and egg production establishments. High protein foods poorly digested by steers is a natural source of flies, a single dropping being capable of harboring perhaps 100,000 fly larvae. Yet pen fences make economical pickup of manure all but impossible and, once collected, the market for steer manure is but a relatively constant fraction of production, while dumping within an economical haul distance is also a problem. Poultry raisers are in a similar situation--opposed by newly established neighbors and at the same time plagued by a problem of manure disposal that is well nigh insurmountable in suburban environments.

Specific problems concern (1) the development of economical procedures for pickup of manures, and (2) the development of modern methods of disposal. Neither is near a satisfactory solution.

Research currently directed to this problem by the University of California at Davis and at Berkeley is concerned with:

1. The development of special machinery for pickup of droppings in the commercial chicken and egg production plants.
2. The possibility of anaerobic digestion of animal manures.
3. The production of algae in ponds fed with animal

manures, followed by harvesting of algae for animal feed or by pumping of the algal slurry onto arable lands through an irrigation technique.

As yet the economic feasibility of none of the three solutions has been demonstrated, although acceptable solutions are urgently needed.

Conclusion

The early scope of sanitary engineering has in recent years been expanded beyond water supply and sewage into other broad areas of environmental health such as air resources, radiological health, environmental sanitation, industrial and agricultural wastes, and water resources development. In many of these areas, just as in the case of water quality control, problems have multiplied faster than research can supply even temporarily satisfactory answers. Answers in one problem area often create new problems in another--i.e., the problems are shifted from water to air, from air to refuse, and from refuse back to water again, in a spiral of increasingly complex nature requiring investigative techniques of increasingly great resolving power. The over-all effect is a slowly losing battle which makes more urgent each year the search for answers in environmental health problems; or offers the alternate prospect of an increasingly aesthetic society living in an increasingly unaesthetic mantle of its own debris.

INFORMATION RETRIEVAL

E. F. Eldridge*

We are here today to discuss research as applied to water pollution and certain other of the environmental sciences. The objective of research is to provide knowledge. Hence, the objective of research in the water pollution field is to provide the technical knowledge necessary to adequately protect the quality of the Nation's water resources.

A great deal of research has and is being done in this field by competent researchers. There is a widely accepted feeling, however, that in spite of the research accomplished in this and related fields, knowledge is not keeping pace with the incipient problem. If this is true, and I am sure it is, then we must step up our research. There is every indication that the research activity in this field will be significantly expanded in the future.

One overlooked fact, however, is that we are not using the knowledge we do have to accomplish the objectives of research. This information is stored away in innumerable journals, pamphlets, bulletins, unpublished reports and raw data files. When I say "we" are not using it, I mean the regulatory agencies who have the responsibility of enforcing pollution control, the consulting engineers, the management of industry with waste problems, land and water resource management agencies and, most surprising of all, the researcher.

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The main reason for this lack of use is that the information is not available in a form which is readily obtainable and usable. I believe you will agree that it is a major, and time consuming job, just to get a complete list of references on a subject. It is an impossible job to read even those articles and reports published in the major current magazines. This job will become insurmountable as the research is expanded in this field.

The following is an example quoted from the General Information Manual of the International Business Machines Corporation, 1960: "There are now being published each year some 100,000 reports, 55,000 scientific journals and more than 6,000 books in the scientific and technical areas. A chemist trying to keep abreast of the literature in his field would fall behind by an estimated 850,000 pages every year even if he devoted his full time to reading."

As much as we need a greatly expanded program of research in this field, of equal, if not more importance, is a mechanism by which the results of research, as well as other types of information relating to this field, can be made available and usable. It seems to me that these are companion requirements.

There are two missing links between the acquisition of knowledge by research and its use. The first is a mechanism by which complete bibliographies of reference material may be readily obtained on specific subjects. This does not involve a new idea. Such mechanisms are in use in many industries and government offices for retrieval of information. In this case I envision a single central location where literature from all pertinent sources is codified and from which anyone desiring a list of references on a particular subject can obtain such a list rapidly and with reasonable assurance that it is complete. It should be understood that this will not be a search for one article, but rather a list of references on a subject. It will not be a library service, nor an abstract service. Therefore, it is only one step, but an important one, in the retrieval process. In many cases, it will be all that is required since the individual or agency making the request now has a select group of publications for reading. The conventional library service can supply the articles.

However, even with this reference list, the recipient may still be stymied by an inability to read, sift and analyse the vast amount of literature which is published on some subjects. This is especially true in the case of regulatory agencies, consulting engineers, industrial and numerous governmental agencies.

The second missing link in this chain, therefore, is a compilation and analysis of the total information available in the literature on each of a number of specific subjects. Thus, if you are working on a problem and wish to know the best of the information available on this subject, you can obtain this from one source.

This again can be done through a central agency established for this purpose and equipped to keep the compilation current. These compilations should not be merely a series of abstracts. To be of the most value the information contained in the compilation must be analyzed as to reliability and completeness. This most certainly does not involve a value judgment on each article.

There are certain recognizable hazards in such an analysis since it does involve decisions and opinions on the part of those preparing the compilations.

Last year I prepared a compilation and analysis of information on Characteristics and Effects of Return Irrigation Water as an example of this type of activity.

Proposals have been made to supply the missing links above and to bridge the gap between the acquiring and use of of knowledge in the fields related to water pollution. These proposals have been recommended to the Public Health Service as one of the areas where the Service can be of the most value to those working in these fields. These projects of information retrieval in conjunction with an expanded research program will assure the best use of the research funds.

I cannot say at this time if or how rapidly these projects will be initiated. I do know that there is a definite interest in information retrieval and hope it will not be too long before a decision will be made and positive action will be taken.

FINANCING OF RESEARCH AND TRAINING FACILITIES, EQUIPMENT, PERSONNEL AND PROJECTS

U. S. Public Health Service

R. H. Holtje*

The Public Health Service offers several types of research grants-in-aid to institutions of learning, state and local governments, private and corporate firms and individuals having interest in health sciences. Of primary interest are the following five types:

WSC
PSC

1. Health research facilities construction grants, intended to assist in providing adequate research "buildings" and equipment.

all institutions in PNW

2. Project training grants, intended to assist schools of public health and sanitary engineering in expanding and improving curricula and staff,
3. Research training grants, intended to assist schools of public health and engineering by giving aid to post baccalaureate students possessing or having potential research talents,
4. Research fellowship grants intended to assist individuals at the pre-and post-doctoral level who have demonstrated [illegible] outstanding research talents, and

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5. Research grants which support specific projects. Each of the grant types are described in greater detail on separate sheets that are included following this paper.

I will enlarge upon the description of research grants, since I believe you may be more interested in this type than any other. In addition, research grants appear to have the greatest potential for assisting in filling in knowledge that now interferes with solving the many serious problems we face in restoring and controlling water quality.

A recent statement of Surgeon General Luther L. Terry concerning future needs in water supply and pollution control has this to say:

> As demands increase, there will not be sufficient water for each consumer to use as he sees fit.
>
> 1. The use of our rivers and streams to carry away our wastes is incompatible with all other water uses and consequently must take lowest priority. This will mean an accelerated program for the construction of water pollution abatement works by both municipalities and industries, which can be brought about by increased enforcement and incentive grants.
>
> 2. The highest order of use to be protected is the drinking water of more than 100 million persons living in urban areas. This will mean more attention to health aspects of water pollution.
>
> 3. The uses of water for industry, agriculture, and our growing recreational needs are taking on increasing significance. These conflicting

interests in water use together with pollution which we do not have means to control make necessary a careful surveillance program over our watercourses to protect the public health and these other vital water interests.

4. Federal, State, local and industrial cooperation in shaping comprehensive programs to control pollution of entire river basins are a "must" if we are to provide water for the developments which demographers and economists predict.

5. An intensified research effort will be necessary to meet the already clear needs of the future. For example: (a) we must be able to identify and predict the health and other adverse effects of many new pollutants reaching our watercourses and removed neither by waste treatment nor modern day water purification; (b) feasible means must be developed to remove toxic contaminants such as the economic agricultural poisons; (c) new scientific disciplines not heretofore employed in water pollution control must be attracted to this field of research.

Perhaps I could serve you best by briefly outlining the current research grant program.

Almost everyone in the field of water supply and pollution control is aware of the intramural research program carried on by the Public Health Service at the Robert A. Taft Sanitary Engineering Center. Perhaps not as well known is the Public Health Service's extramural research program in water supply and pollution control conducted quite independently of "SEC." I refer to the extramural program of basic and applied research developed by the National Institutes of Health. NIH has awarded grants in this field for the past 14 years and a total of 666 grants amounting to $6,592,926 have been awarded.

The Surgeon General in his report on Environmental Health to the House Committee on Appropriations, submitted in January, 1960, recommended that research grants and research training grants be made available to the environmental health programs of the Public Health Service. The 1961 House report (D/HEW Subcommittee of the Committee on Appropriations) suggested that the 1962 budget be presented with all identified environmental health aspects transferred to the appropriations of the environmental health programs, including the grants now administered by the National Institutes of Health. The "Report of the Study Group on Mission and Organization of the Public Health Service," proposed a Bureau of Environmental Health and included provision for administration of research grants and research training grants.

The 1962 House Appropriations Committee has considered the proposed changes. In anticipation of favorable Congressional action, the Division of Water Supply and Pollution Control has been formulating procedures and policies necessary to operate the proposed expanded extramural research program. A Research and Training Grants Branch, headed by Mr. Harry A. Faber, has been organized within the Division.

Since several of those attending the Symposium have currently active research grants or have applications in process at NIH, it will be of interest to them to know that the Division plans to conduct its extramural research program in a manner quite like NIH. In fact, plans now call for: (1) use of the same application forms, (2) submission of applications through NIH channels and (3) use of the NIH dual review and approval organization. The current NIH rules, regulations and policies will be retained, at least, for the present.

NIH supported research grants now in force have already been identified as appropriate for transfer to the Division of Water Supply and Pollution Control. Actual transfer will take place when funds are made available to the Division -- hopefully early in FY 1962. The 1962 budget request submitted is $2,064,000 for research grants in water supply and pollution control. This amount will be sufficient to meet continuation obligations connected with the transferred grants.

Scientific freedom is considered to be the keystone of the research grant program. The investigator is expected to conceive his own project. It is expected that the investigator will use his own best judgment concerning its relevance to national regional or local water quality needs.

The ability of the research investigator is an important factor in the review of an application for a grant. The applicant should clearly define the project and aims in specific terms, and precisely describe the approach and methods, the starting day and the length of project in months or years.

The investigator should show that he knows what has been done on the subject by others, relate his own publications, if any, to the proposal and indicate the significance of the proposed research. He is expected to show, by his professional background, that he is able to carry out the proposal expertly. He should recognize his own weaknesses and include in the application co-investigators or provision for consultants, if warranted.

The site of the proposed research is important. Are the facilities adequate? Is the proper equipment available?

Lastly, the budget for the proposal must be reasonable and appropriate for the project, the site and the institution.

The investigator has freedom to judge and act. If in his judgment, changes in the proposed project are necessary after it is started, he is permitted to make them to achieve his stated aims. If more funds should be spent on needed extra equipment instead of on supplies, travel or other budgeted items, he is free to do so. All grant funds are, of course, subject to fiscal audit and it is prudent to report major changes.

Perhaps it would be helpful to briefly describe the application review and approval process.

Upon receipt at the Division of Research Grants, at NIH, each application is assigned for review to one of forty study sections and an Institute -- or hopefully in FY '62 to one of the environmental health divisions. At the study section level the application is reviewed with primary emphasis on the scientific merit of the investigator, his plans, aims, site and other factors. Recommendation is made for approval, disapproval, or deferral and those applications approved are given a priority rating by each study section member.

Study section recommendations are then transmitted to the assigned Institute -- or environmental health division -- for review by one of six National Advisory Councils. The Council may concur with the study section recommendations or may reverse or alter them. If the Council's recommendation is for approval, a recommendation is made to the Surgeon General of the Public Health Service that payment be made on a priority basis.

Practically, all applications in the water supply and pollution control field are assigned to the Environmental Sciences and Engineering Study Section. A few may be assigned to other study sections concerned with toxicology, bacteriology, and mycology, radiation, dentistry (fluorides), tropical medicine and parasitology.

The Environmental Sciences and Engineering Study Section presently has 18 members representing several professional disciplines. The members are non-federal scientists who serve as consultants. Most are university people who are outstanding experts in their fields.

Each application is reviewed very carefully by at least two of the study section members before a scheduled meeting. Written critiques are required. At the meeting, the discussion leaders make their oral presentations. A vote for approval is followed by assignment of priority.

The second review is accomplished by the Council following the same general pattern but emphasis here is more strongly oriented to broad PHS program policy. Practically all of the applications involving water supply and pollution control are reviewed and passed upon by the National Advisory Health Council, members of which are again mostly University oriented. They are appointed as consultants to the Surgeon General on the basis of their proven scientific management and executive skills.

Since experience shows that 41 percent of the applications submitted are disapproved, it would be well to examine reasons why they are disapproved. Considerable time and thought is in volved in preparing an application and disappointment to the applicant who is turned down is undoubtedly keen. Dr. Ernest Allen, who is associate director for research grants at NIH, outlined the disapproval reasons in Science (11/25/60) as follows:

Class I: Problem (58 percent)[1]

1. The problem is of insufficient importance or is unlikely to produce any new or useful information.

2. The proposed research is based on a hypothesis that rests on insufficient evidence, is doubtful or is unsound.

3. The problem is more complex than the investigator appears to realize.

4. The problem has only local significance, or is one of production or control, or otherwise fails to fall sufficiently clearly within the general field of health-related research.

5. The problem is scientifically premature and warrants, at most, only a pilot study.

6. The research as proposed is overly involved, with too many elements under simultaneous investigation.

7. The description of the nature of the research and of its significance leaves the proposal nebulous and diffuse and without clear research aim.

Class II: Approach (73 percent)

8. The proposed tests, methods, or scientific procedures are unsuited to the stated objectives.

9. The description of the approach is too nebulous, diffuse, and lacking in clarity to permit adequate evaluation.

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[1] Shortcomings found in study-section review of 605 disapproved research grant applications, April-May 1959. All percentages are to the base 605.

10. The over-all design of the study has not been carefully thought out.

11. The statistical aspects of the approach have not been given sufficient consideration.

12. The approach lacks scientific imagination.

13. Controls are either inadequately conceived or inadequately described.

14. The material the investigator proposes to use is unsuited to the objectives of the study or is difficult to obtain.

15. The number of observations is unsuitable.

16. The equipment contemplated is outmoded or otherwise unsuitable.

Class III: Man (55 percent)

17. The investigator does not have adequate experience or training, or both, for this research.

18. The investigator's previous published work in this field does not inspire confidence.

19. The investigator's previous published work in this field does not inspire confidence.

20. The investigator proposes to rely too heavily on insufficiently experienced associates.

21. The investigator is spreading himself too thin; he will be more productive if he concentrates on fewer projects.

22. The investigator needs more liaison with colleagues in this field or in collateral fields.

Class IV: Other (16 percent)

23. The requirements for equipment or personnel, or both, are unrealistic.

24. It appears that other responsibilities would prevent devotion of sufficient time and attention to this research.

25. The institutional setting is unfavorable.

26. Research grants to the investigator, now in force, are adequate in scope and amount to cover the proposed research.

The question is often asked, "What type of research project should be submitted for support?" Both basic and applied research projects are desired. Demonstrations (field surveys) are also in order. The scope is water in the environment.

Since the purpose of the research grants program is to support research in neglected areas, it appears that the field is wide open for investigation. Sufficient basic knowledge to adequately manage the quality of water resources is not presently available.

The water supply and pollution control program in research and training grants is interested in seeking qualified scientists of all disciplines who want, need and request, support to help reach our broad goal. That goal is a better understanding and utilization of natural and induced phenomena in areas such as water resources and supply, sewage, industrial and other wastes, limnology, potamology, oceanography and their relation to health, comfort and welfare.

Finally, with respect to what type of research is needed, I refer you to Mr. Eldridge and his Research and Technical Consultation Project. He has prepared lists of projects related to problems in the Northwest.

Each investigator should examine the areas he knows best and attempt to fill the gaps he sees. The packs containing applications for grants may be obtained by writing to The Research and Training Grants Branch, Division of Water Supply and Pollution Control, Public Health Service, Washington 25, D.C. or E. F. Eldridge.

DISCUSSION FOLLOWING HOLTJE PAPER

Q. Is there anything new that research people should know with respect to how applications are completed and submitted?

A. Yes, the most recent application forms now have a pink colored draft copy that may be removed and used by the applicant as a work sheet to complete the form in detail. If the scientist so desires, this copy may be submitted informally to Mr. Eldridge who will endeavor to help in the preparation of the application.

Q. What is the status of the project when a grantee investigator moves from one school to another?

A. Research grants may not be transferred directly from one institution to another when the investigator moves, but the new institution may submit an application in his behalf. Ordinarily, the grant at the original institution is terminated. However, the original institution may request approval to transfer responsibility to a new investigator, if justified. The situation is subject to PHS review and approval.

Q. How is the work in connection with PHS supported projects evaluated:

A. There is no formal technical evaluation made of the research. However, annual progress reports are required to be submitted with requests for grant continuation. A terminal report is required. If the work has been published, reprints are accepted in lieu of reports. The investigator is encouraged to publish his results and in almost all cases he does submit them for publication in a national scientific journal.

While there is no PHS evaluation, we feel that the careful original review of the applicant and application is sufficient to assure reasonably high quality research. In reality, evaluation is made by practicing fellow scientists who are expert in the area of the research undertaken. Finally, regardless of the research outcome, a promising idea has been explored.

We do not attempt to indicate whether the work was good or bad.

Q. After a project has been conducted over the first year of a grant, who evaluates it for the next year?

A. The study section evaluates past performance in considering requests for continuation years. An investigator who does not produce is unlikely to confince a study section he is worth a risk of grant money on a continuation request -- or perhaps a new project.

It was volunteered from the floor that most university people realize and adhere to the "publish or perish" routine. The individual who grows professionally has to show by his published material that he is capable of doing research. If he does not, the university may be unwilling to sponsor new requests for grants.

Q. We are having difficulty in getting competent scientific people. Are you experiencing any difficulty along this line?

A. If the question relates to the difficulty in inducing a sufficient number of competent investigators to undertake research by the extramural grant mechanism, the answer is a qualified no. Each year there are more high quality approved applications for funds than there are funds available.

If the question relates to the ability to attract a sufficient number of scientific people to the PHS, the answer is yes. There is a definite lack of trained people in this field.

Q. You mentioned that an industrial firm is eligible? Please explain.

A. Yes, industrial firms are eligible, but we have not had many applications from this source. I guess too, that industrialists suspect that while they are eligible, the review given an industrial application may not be as sympathetic as that given an application submitted by a non-profit organization. However, we generally have supported one or two of this type of grant each year.

Q. What records are available to the study section in their review? Do they have any records of what has been done before on which to judge other research applications?

A. The principal assigned reviewers make their review at their "home base" and study section members have their own sources of information. Study section members best qualified to review specific applications are generally expert in the area of the proposed project. The application contains information concerning earlier grants on the general subject by the applicant.

At the meeting, the executive secretary has appropriate information at hand gathered from his files on each grant and the applicants grant history. The secretary's information is also supplemented by the NIH data collection, storage and retrieval system involving data on over 10,000 grant awards. Most questions can be answered by study section members based on their expert knowledge, and personal acquaintance with the somewhat limited number of people working in this field.

Incidentally, salaries must conform to accepted salary scales current at the sponsoring institution. There is a double check made too, concerning the ability of the applicant to spend the amount of time indicated in the application.

Q. What are the other sources of Federal funds available for researchers?

A. Information regarding sources of federal research grants other than PHS is contained in the last item of these Proceedings.

Q. Are these grants available to agencies within the Federal government?

A. No. Federally employed persons or Federal agencies are not eligible. State agencies are, of course, eligible.

Q. May a state agency undertake to develop a project application using university based people as their researchers?

A. Yes, but in any case the named principal investigator is expected to carry out the project, whether he is university based or state agency based.

We encourage State Health Agencies to undertake research in water supply and pollution control using the research grant mechanism.

Q. What provision is made for an individual who is perhaps a member of a State Health Department who has an idea in mind and who wishes to investigate it?

A. He should submit an application with the approval of his employer who is entitled to decide whether or not the research would interfere with the man's job, if accomplished outside working hours. It is best to seek the sponsorship and endorsement of the State agency.

Q. I had in mind a man who is leaving association with any institution--who wants to carry on the research by himself.

A. He can go it alone, if he wishes to attempt it, but he must be fully qualified and demonstrate that the project can be accomplished. I suspect there would be a site visit made by two study section members to ascertain the full facts before a favorable recommendation is made of such an application.

Q. Most of the universities are unwilling to go into research as an end in itself. They insist that the investigator must be a member of their teaching faculty. A man who has an idea has a pretty hard time using university facilities unless he gets a member of the faculty to put his name on the research application. If he wants to go through a university, the university must have seen this application, reviewed it and put its sponsorship on it.

If he doesn't have the facilities but has the capabilities he can include equipment in his application. If there is a doubt, members of the study section will be assigned to make a site visit.

Q. This program is aimed at stimulating high quality research. How might it come about that the immediate research problems of the operating agencies may be solved?

A. There is provision for all types of research, but we are thinking of asking for a separate fund to support demonstrations. This type of grant would involve investigations, studies and research but would be available for those field projects that would reduce the time lag between discovery of new useful knowledge and its application. We would guard against these funds being used for survey type field studies normally accomplished by State agencies.

Q. What do you mean by "operations research?"

A. This is a more specialized type of study and may be accomplished by the research contract mechanism. The Sanitary Engineering Center is engaged in this direction.

The contract is particularly valuable when an organization has an extraordinary talent or specialized equipment to do a specific job.

This contract type of research is different than the undirected type of research in that the objective and to some extent the methods are specified.

Q. I think that everybody knows that this two million dollar a year program is inspiring more development in sanitary engineering than would normally be possible. Some schools need this support to survive in sanitary engineering. What do you think of the future of the research grants program if the proposed regional laboratories of the PHS are built?

A. I think the job is so big that we could profitably have a dozen labs around the country and still only scratch the surface. These laboratories would stimulate research in the various institutions. This was the case when the National Institutes of Health increased in magnitude. The research grants program also increased by several hundred per cent. These expansions have gone along together. Neither one of them has suffered as a result of growth.

Q. The National Institutes of Health started with a little intramural group. Later they requested and obtained from Congress money for extramural research. Before long you could hardly find the intramural people. But if you visit Bethesda you will see the huge clinical center that enjoys world fame. This is the intramural phase of these research programs. Actually it has been literally pulled along with the growth of the extramural program which has grown at a much faster rate. I am sure that this will be the case of the regional laboratories. They will stimulate more research on the extramural and local level.

Q. What is the present status of the health research facilities grant program? I understand that it has run out.

A. Originally, it was a three year program starting in 1956. It was renewed again by Congress for three years to July 30, 1962. I assume that it will be continued. It is a good program and has done a lot of good. It has helped several sanitary engineering schools. In my opinion we need the regional laboratories and we need the extramural approach too. These laboraties can be an aid to increasing the scientific manpower in this field.

This is important. There are 67 institutions that have aspirations to give degrees in sanitary engineering. There are a few who have no real facilities and hope that they can get both the facilities and the manpower to teach, using Public Health Service funds. The student demand for this kind of thing has not kept pace with the potential for facilities. If this continues, I think we would be in a situation where we might finance needed research without it being related to the education program. This doesn't mean it is a bad thing, but it would mean that the institutions would have to change their research emphasis some, rather than as an adjunct to producing graduates in sanitary engineering.

Q. What is the relationship between your intramural and extramural expenditures?

A. Extramural money is presently $2,064,000 plus five per cent for administration. It is very small. But the old and the new Federal administrations have urged increases over present research funds. The chances are that Congress will look favorably on this request. Also, it is felt that the contract device would be a useful tool in gaining information in terms of program requirements. I think that Congress itself has not appropriated much money on contracts. We hope that we are getting close to the point where we can use this device.

Q. How many men make up the study section and how many men make up the Council?

A. There are 18 men on the study section. They represent several professional disciplines. The study section is a composite group of sanitary engineers, bacteriologists, and other professional disciplines. There is no limit to the number of study section members permitted. We have one of the largest study sections because we have the most diverse type of applications.

The Council has twelve members. This is fixed by law. Incidentally, the study section meets three times a year and spends three days at each meeting reviewing applications. The same goes for the Council.

However, three days is not all the work that goes into this review. The reviews are made by study section members before they arrive in Washington and further, some are reviewed at SEC by the specialists.

There is one exception to the statement made about non-federal reviewers. One Public Health Service man is on the study section. The exception was made because of the unusual range of competencies at Cincinnati at the Sanitary Engineering Center.

The Division of Water Supply and Pollution Control, as I have said earlier, depends upon NIH operations for review and approval of applications. The Division has no guarantee that NIH will continue to furnish review and approval beyond one or two years. We are expected some time in the future to furnish our own study section and establish our own National Council. The new Council will probably be built around the proposed Environmental Health Bureau which encompasses water pollution, air pollution, occupational health, accident prevention, food and other groups, but we will probably create our own study sections.

FURTHER INFORMATION REGARDING PUBLIC HEALTH SERVICE (National Institutes of Health) GRANTS

At the present time specific information regarding Public Health Service grants is contained in two pamphlets which are available by request to the National Institutes of Health, Bethesda 14, Maryland. Volume I describes grants for (1) research projects (2) construction and equipping of research facilities, (3) field investigations, and (4) special projects. Volume II describes (1) research fellowship grants, (2) direct traineeship grants and (3) training grants.

Mr. Holtje in his statements to this symposium covered in some detail the research grants program. Essential features of other of these grant programs are presented in the following pages.

Health Research Facilities Construction Grants

Background and Purpose.

Purpose: Grants for large-scale construction of health research facilities were not made prior to 1948. In that year, Congress appropriated $2,303,000 for grants for construction of research facilities to be made through the National Cancer Institute. Additional grants for such construction were made by the National Heart Institute in fiscal years 1950 through 1952 under general authority conferred by Section 433 of the PHS Act as amended by the Act of August 15, 1950, (42 USC 289c). The total from the National Cancer Institute thus amounted to $16,303,000 and from the National Heart Institute $6,059,000. Support of this program was not continued by Congress with the outbreak of the Korean conflict.

In 1956, in the Health Research Facilities Act (Public Law 835), the 84th Congress authorized establishment of the National Advisory Council on Health Research Facilities and appropriated $30,000,000 for the first of three years, for grants for construction, on a matching basis, of facilities for research in the sciences related to health, including the fundamental sciences. In 1958 the three-year program was extended an additional three years by the 85th Congress.

The general purpose of Congress to promote research toward the prevention and cure of the physical and mental diseases and impairments of man has been served by all grants made for construction of health research facilities in that such construction makes available increased laboratory and accessory space and related scientific equipment in public and private non-profit institutions.

The regulations recommended by the National Advisory Council on Health Research Facilities and approved by the Surgeon

General and the Secretary (42 CRF, Part 57) require particular consideration be given in the use of the available funds to (1) research facilities contributing to research in disciplines or diseases which have the most urgent need, (2) institutions or localities with broad research programs and potentials, and (3) various geographical areas of the Nations having at present relatively few such research facilities.

Financial Aspects

The fiscal data on grants for construction of health research facilities are as follows:

Health Research Facilities Grants
Fiscal Data

Year	Appropriation
1957	$30,000,000
1958	30,000,000
1959	30,000,000
1960	30,000,000
1961	30,000,000

Method of Distributing Funds

Funds for construction of health research facilities are distributed in response to grant applications from universities or other public or non-profit institutions recommended by the National Advisory Council on Health Research Facilities and approved by the Surgeon General. Evidence that the purposes and intent of the Health Research Facilities Act will be served is provided in each case. The steps in processing an application are as follows:

1. Universities and other institutions make applications to the National Institutes of Health for a Health Research Facilities Grant. In the application the need is detailed and the prospective cost stated. The application is received in the Division of Research Grants and presented to the National Advisory Council on Health Research Facilities.

2. The Council evaluates each application with respect to its potential value in expanding health research in the Nation and subsequently makes recommendation to the Surgeon General that a grant in a specified amount be made, or that it not be made.

3. The Surgeon General, at his discretion, awards support to an applicant institution in the amount recommended by the Council, or in a lesser amount. In no case is the amount to exceed 50 percent of the total necessary construction costs of the research portion of the facility; the remaining sum is provided by the institution through funds available to it from non-federal sources.

The sum awarded to the grantee institution is paid in installments consistent with construction progress.

Matching Requirements

The Federal grant may not exceed 50 percent of the necessary cost of the research facilities for which grant is made.

Source of Data

The principal sources of information are the grant applications submitted by universities or other public or non-profit institutions.

Legal Basis

Title VII of the Public Health Service Act as amended by the Health Research Facilities Act of 1956, 70 Stat. 717; P. L. 835, 84th Congress; Title VII extended through June 30, 1962; P. L. 777, 85th Congress (42 USC 292).

Additional information may be secured from the Chief, Division of Research Grants, National Institutes of Health, Bethesda 14, Maryland.

TRAINING GRANTS AND TRAINEESHIPS

Background and Purpose

Purpose. Training programs sponsored by the National Institutes of Health originated in 1937 with the passage of the National Cancer Act. The early beginning was modest and involved only the provision of part-time support of a few trainees by the National Cancer Institute. Since that time, the training grants and traineeships programs of the National Institutes of Health have steadily increased in the total amount of support available as well as in the number of scientific areas involved. Training grants and/or traineeships falling within their particular fields of interest now are awarded by the National Cancer Institute, National Heart Institute, National Institute of Arthritis and Metabolic Diseases, National Institute of Allergy and Infectious Diseases, National Institute of Mental Health, National

Institute of Neurological Diseases and Blindness, National Institute of Dental Research, and the Division of General Medical Sciences.

The general purpose of these awards is to support training either as programs within an institution or as stipends to an individual in research and teaching in all fundamental sciences relating to medicine and health. Many of these programs are directly related to research in the prevention, alleviation, and cure of the physical and mental diseases and impairments of man. Training grants and traineeships are two types of awards that supplement each other and make possible a broad, integrated program of training. The first type of award provides funds to an institution to support a particular training program, while the second type of award provides stipends to individual trainees to enable them to undertake special training at at the institution of their choice.

Grants for training of undergraduates are awarded to medical, dental, and osteopathic schools as well as schools of nursing and public health to enable them to establish, expand, or improve undergraduate instruction relating to prevention, diagnosis, and treatment of cancer, cardiovascular disease, mental diseases, and related gerontological conditions. Under-graduate training grants are awarded for the following amounts:

Institute	Medical Schools		Dental Schools	Public Health Schools	Schools of Nursing	Schools of Osteopathy
	4-Year	2-Year				
Cancer	$25,000	$ 5,000	$5,000	a	a	$25,000
Heart	25,000	15,000	a	$15,000	a	25,000
Mental Health	25,000[b]	15,000[b]	a	a	$25,000[c]	15,000

a. Not made

b Present general limit on teaching funds. In addition, medical schools and schools of osteophathy may request up to 12 $600 units (plus indirect costs) for student stipends for extracurricular clinical or research training in psychiatry.

c This maximum, to be used in a limited number of instances, has been recommended for undergraduate collegiate schools.

Graduate training grants are awarded mainly for the purpose of assisting institutions to establish, expand or improve their research and academic training programs and to increase the number and caliber of trained personnel in fields constituting the primary interest of the various Institutes. In addition to providing sums for the support of the institutions' programs, these grants also provide funds for stipends awarded by the institution to personnel who are undergoing training.

Traineeships are provided as individual stipend awards directly by the National Institutes of Health to qualified physicians and other scientists in order that they may undergo advanced, specialized training in one of the fields of the health sciences.

__Financial Aspects__. Funds that have been made available for this program are tabulated below:

1938	1,395a
1939	41,832a
1945	29,000
1946	25,000
1947	250,000
1948	2,809,000
1949	3,930,000
1950	6,415,000
1951	6,920,000
1952	$7,392,000
1953	8,194,000
1954	10,813,000
1955	11,051,000
1956	14,502,000
1957	28,075,000
1958	32,932,000
1959	50,102,000
1960	75,037,000
1961	110,000,000

a Represents Obligations.

__Method of Distributing Funds__

Training grant funds may be awarded to an institution in the name of a specific program director, provided the application submitted has been recommended by a National Advisory Council and approved by the Surgeon General, after application is given favorable technical review by a training grant committee composed of outstanding non-federal scientists and educators.

The major criteria used in evaluation are as follows:

1. An assessment of the academic and professional background of the training program director, particularly concerning his previous success and reputation in the training of scientists and educators in the specific field or area indicated in the application.

2. The facilities and reputation of the institution, and of the departments concerned.
3. The national needs for scientific manpower in a particular field or area.
4. The availability of funds in light of the amount requested for the specific program.
5. Other pertinent matters, such as geographical distribution when two or more applications seem to have approximately equal merit.

Traineeships are reviewed by advisory committees made up of the staff of the Institute concerned, plus various ad hoc consultants The criteria used are similar to those adopted for the research fellowships program and generally include: (1) an application consisting of personal data and information, academic and professional history, record of previous employment, the applicant's statement as to the manner in which the requested training will fit him for his proposed career of clinical research, teaching or public service; and (2) letters of reference. The trainee is free to select any training institution approved by appropriate professional accrediting bodies; in all cases, however, he must be accepted in writing by a faculty sponsor before final completion of the application and traineeship award. Traineeship applications are not reviewed by a National

Advisory Council, although in some cases the National Advisory Council is required by law to establish the maximum number of traineeships which that particular Institute may award. The stipends provided regular trainees vary somewhat in the various Institutes but are commensurate with the maturity, training and objectives of the candidates selected for traineeship awards. The traineeship provides a basic stipend, tuition and fees, and in some instances, travel and dependency allowances. Special trainees are awarded stipends established on an individual basis with due concern for their academic and professional backgrounds, their years of previous training and appropriate related matters.

Matching Requirements

No matching of funds are required.

Source of Data

The sources of information upon which training grants and traineeships are awarded include the applications filed by institutions and individuals, data on national manpower needs, and evaluations by eminent authorities in the respective fields concerned.

Legal Basis.

The legal authority for awarding training grants and traineeships is conferred by Section 433 (a), Public Health Service Act, as amended (42 USC 289c).

SOURCES OF FEDERAL RESEARCH GRANTS
(Other than Public Health Service)

A number of Federal agencies are authorized to make grants to non-profit organizations and educational institutions for conducting research on subjects which come within their interests. Some of these interests involve or are related to water supply, water pollution or environmental health fields.

Every effort has been made on the following pages to present a very brief, accurate description of the grant programs of some of these agencies, their areas of interest and other pertinent information. (This information has been abstracted from publications of the agencies.) This is not a complete list of sources, but does contain a list of agencies most likely to make grants in the above mentioned fields. More detailed information can be obtained by writing for the brochures mentioned.

Of possible interest is a pamphlet costing one dollar and printed by the Social Legislation Information Service, called, "Federal Agencies Financing Research." This may be secured from 1346 Connecticut Avenue, N.W., Washington 6, D.C.

Department of the Army
Army Research Office

SCIENTIFIC RESEARCH GRANTS, 1960.
No charge for brochure.

Office of the Chief of Research and Development
Headquarters of the Army
Washington 25, D.C.

Public Law 85-934 authorizes the Department of Defense, "Where it is deemed to be in furtherance of its objectives, to make grants for support of basic scientific research to nonprofit institutions of higher education and to nonprofit organizations whose primary purpose is the conduct of scientific research..."

The Department of the Army defines research and development as follows: "Research: The theoretical or experimental search for fundamental knowledge and control of a particular substance or physical phenomenon. When this search is conducted without any specific goal of applying the results to a particular problem at hand, it is "basic research." While the Army does support some basic research, its greatest research financial outlayis in the area of applied research. Development: The practical application of investigative findings and theories of a scientific and technical nature. It includes the construction and testing of prototype models and devices."

Department of the Army grants may be made for periods up to five years...An informal annual report is required unless the grant is for a period of one year or less, then only a final report is required. Fiscal reports are required annually.

The instrument used to provide research monies is usually a contract. This is worked out following the acceptance of a proposal.

The actual research and development work of the Army is carried out by the Technical Services, whose main function is to support the combat troops. These services, seven in number, viz., Corps of Engineers, Ordnance Corps, Quartermaster Corps, Signal Corps, Transportation Corps, Chemical Corps, and Army Medical Service.

Certain of the aforementioned Technical Services are of particular interest to those doing research work in water supply and water pollution fields. Among the principal interests of the Corps of Engineers are port facilities, water supply and sanitation, waste disposal, water purification equipment, siltation and other water quality changes due to impoundments and other water resource problems. Listed under the principal interests of the Chemical Corps are: biological agents, chemical agents and certain chemical, biological and radiological problems. Also of possible interest would be the Army Medical Services, however the Army Medical Service civilian research is supported primarily by cost-reimbursable contracts, and where the cost of services may be predetermined, by fixed-price contracts. Research grants are not made by the Army Medical Service.

Additional information may be secured from "Contractors Guide," Research and Development in the U. S. Army, prepared by the Department of the Army, Washington 25, DC, 1959.

AEC - "Revised Guide for the Submission of Research Proposals"
United States Atomic Energy Commission
Washington 25, D.C.
February 8, 1954

The Atomic Energy Commission is directed under the Atomic Energy Act of 1946 as follows:

Research Assistance. The Commission is directed to exercise its powers in such manner as to insure the continued conduct of research and development activities in the fields specified below by private or public institutions or persons and to assist in the acquisition of an ever-expanding fund of theoretical and practical knowledge in such fields. To this end the Commission is authorized and directed to make arrangements (including contracts, agreements, and loans) for the conduct of research and development activities relating to:

(1) nuclear processes;
(2) the theory and production of atomic energy, including processes, materials, and devices related to such production;
(3) utilization of fissionable and radioactive materials for medical, biological, health, or military purposes;
(4) utilization of fissionable and radioactive materials and processes entailed in the production of such materials for all purposes, including industrial uses; and
(5) the protection of health during research and production activities. (This item includes waste disposal problems.)

Through its Divisions of Research, Biology and Medicine, and Reactor Development the AEC contracts with independent institutions for research in fields related to atomic energy. Under these contracts the universities, colleges, industrial laboratories and other research institutions contribute to scientific progress in fields related to the development and use of atomic energy including waste disposal problems and radiological levels in the environment.

Two types of instruments are used for sponsoring research: "The Cost-Sharing Lump-Sum Contract" - a type of arrangement which the Commission has adopted for assisting research in independent institutions. These contracts can be used when the annual cost to the AEC is less than $100,000 and can be estimated with reasonable accuracy in advance.

Cost Contracts. Projects requiring higher contributions from the AEC or those of which the costs cannot be estimated with reasonable accuracy.

In 1954, through its Division of Biology and Medicine, the AEC was given the authority to make grants of funds to educational institutions for the acquisition of equipment to be used in courses of study of nuclear technology as applied to the life sciences. "The program is designed specifically to assist colleges and universities to acquire the various items of equipment which are needed to present adequate and meaningful laboratory course work. The funds are intended to provide teaching aids, demonstration apparatus, and student equipment to be used in educational and training courses rather than equipment for use in research activities. The addition of radiation biology in courses already offered, or establishment of new courses in that area are equally acceptable." The construction of buildings and other types of housing facilities are not covered by these grants.

Additional information on these equipment grants related to the life sciences may be secured by asking for: "Grants for Purchase of Equipment in the Fields of Nuclear Technology as Applied to the Life Sciences - Division of Biology and Medicine." October, 1960 (Rev.)

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Funds are also available from the AEC through the 1954 Atomic Energy Act, for the purchase of equipment and loans of nuclear materials to educational institutions for use in courses of study in nuclear technology as applied to engineering and physical sciences. "The general intent of these two programs is to enhance the training of increased numbers of scientists and engineers well versed in nuclear phenomena and its applications. Consideration of proposals for such awards is contingent upon evidence that the equipment and materials desired will be utilized in study courses so oriented. Proposals should be directed toward teaching aids, demonstration apparatus and student laboratory equipment and materials to be used for instruction purposes rather than research, though research use may be a peripheral benefit on a "non interference basis."

Additional information on these equipment grants related to the physical sciences and engineering may be obtained from: "Guide for Submission of Proposals for Equipment Grants and Loan of Materials in Physical Sciences and Engineering," Coordinator of Nuclear Education and Training, Office of the Assistant General Manager for Research and Industrial Development. United States Atomic Energy Commission, Washington 25, D.C., 1961.

AFOSR - Air Force Office of Scientific Research
Air Force Research Division
Air Research and Development Command
United States Air Force
Washington 25, D.C.
August 1960

The Air Force Office of Scientific Research is the major Air Force activity for sponsoring basic scientific research by contract or grant. This Research activity maintains a flexible system of consideration of applications for grants and requires no set form of application or area of research. The general disciplines which the Air Force is interested in are: aeronautical sciences, chemical sciences, life sciences, including biological sciences, mathematical sciences, physical sciences and solid state sciences.

In addition to the brochure mentioned above there is available a "Guide for the Preparation of Contract Proposals, Headquarters, Air Force Office of Scientific Research, Washington 25, D.C., November 1960. This guide outlines the preliminary proposal and information regarding the formal proposal.

The principal areas of interest involving subjects related to the environmental health field are those of "space" travel and waste disposal problems at installations. The latter includes oil, detergents, etc.

NSF - National Science Foundation
Washington 25, D.C.
January, 1960

"Grants for Scientific Research"

The National Science Foundation Act of 1950, as amended, authorizes the Foundation to initiate and support basic scientific research and programs to strengthen scientific research potential.

The Foundation's approach to the administration of grants for basic research rests on the belief that institutions and scientists alike wish to share, with the Foundation, responsibility for the administrative, financial, and scientific integrity of the program.

The Foundation research grant instrument is a letter signed by the Director. It contains a minimum of express conditions which upon acceptance of the grant will be binding upon the grantee. These conditions relate to the general nature and scope of the research, revocation of the grant, return of unused funds, and patent rights. Grants from the Foundation may be made for periods up to five years.

The National Science Foundation will entertain proposals for support of basic research in all areas of science. The fields of science currently supported include but are not limited to: astronomy; atmospheric sciences, including meteorology and weather modification; biological and medical sciences, including developmental, environmental, genetic, metabolic, molecular, regulatory, and systematic biology, and psychobiology; chemistry; earth sciences, including geochemistry, geology, geophysics, and oceanography; engineering sciences, including chemical, civil, electrical, and mechanical engineering, metallurgy, and engineering mechanics; mathematical sciences; physics; and social sciences, specifically anthropology, social psychology, sociology, economics, demography, linguistics, economic and social geography, and the history and philosophy of science.

It should be noted that the National Science Foundation programs support other scientific activities, such as establishment and modernization of major research facilities; sponsorship of scientific conferences, symposia, and institutes; scientific education projects; fellowship programs; teacher and course content improvement projects; dissemination of scientific information, including support of scientific publications; and science policy studies. Inquiries by persons interested in these other Foundation programs are invited.

ONR - Office of Naval Research
Department of the Navy
Washington, D.C.

"Contract Research Program" (Rev. Sept. 1959)

Since its establishment in 1946 under Public Law 588, 79th Congress, the Office of Naval Research has played a central role in bringing scientific research to bear on naval problems. Part of the ONR program is conducted in its own laboratories and part is sponsored programs in universities, nonprofit institutions, and industrial laboratories.

One important phase of the work of ONR is its sponsorship of a broad program of basic research in selected scientific fields having important bearing on Navy problems. Support in these fields is given to proposals having the greatest scientific merit, with careful consideration given to the competence of the investigator and to the facilities available for the research. ONR recognizes that basic research should not be impeded by security restrictions. In unclassified projects, investigators are encouraged to communicate their ideas to their colleagues, and to publish their results in recognized scientific journals.

In addition to its basic research program, ONR supports a major applied research program and constantly looks for new ideas or principles which may lead to the development of new weapons or warfare techniques.

The ONR Contract Division has pioneered in adapting standard Navy contract procedures to the requirements of a sponsored research program. Flexibility has been achieved through standard types of open contract which permit a simplified relationship between the Navy and the contractor. Contractual and grant procedures are centralized in the Contract Division, ONR, Washington, with major aspects of contract administration delegated to ONR Branch Offices, Resident Representatives, and other Navy field offices.

Under Public Law 85-934 the Office of Naval Research is now authorized, where it is deemed to be in furtherance of its objectives, to make grants to nonprofit institutions of higher education and to nonprofit organizations whose primary purpose is the conduct of scientific research.

Research sponsored by the Office of Naval Research results in many inventions of significance in military and scientific affairs. The Navy's right to use these inventions as expressed in licenses or assignments is a basic product of the research program. The ONR Patent Counsel provides consultation and advice to contractors and their inventors on matters of patent interest to the Navy.

NASA

Office of Research Grants and Contracts
National Aeronautics and Space Administration
Washington 25, D.C.
January 1961.

NASA Objectives - Section 102 of the National Aeronautics and Space Act of 1958 entitled "Declaration of Policy and Purpose," defines the long-range objects for NASA as follows:

(1) The expansion of human knowledge of phenomena in the atmosphere and space; (This includes environmental problems of space travel such as food supply and water utilization.)
(2) The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles;
(3) The development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space;
(4) The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;
(5) The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and without the atmosphere.

Pursuant to these objectives the active participation of the scientists and engineers of universities and other institutions is fostered and encouraged. NASA sponsored research is classified under three main headings: Fundamental Research, Space Flight Research, and Life Sciences Research.

Grants - Research grants for the support of fundamental investigations are issued to non-profit scientific and educational institutions. These grants may be made for up to three years.

The National Aeronautics and Space Administration ordinarily uses four instruments for sponsoring research: Research Grants, Fixed-price Contracts, Cost-type contracts, and Inter-Agency Transfers.

Records are required on each grant or contract and status reports are periodically required. All accounting records are subject to inspection and audit.

USDA - The U. S. Department of Agriculture
Agricultural Research Service

"Questions and Answers on Agricultural Research"
July 1960
On sale by the Superintendent of Documents,
U. S. Government Printing Office,
Washington 25, D.C.
Price 25¢

The United States Department of Agriculture and the State Agricultural Experiment Stations are engaged in many types of research activities, among them soil and water conservation research. These activities are carried on largely at the Experimental Stations at land-grant colleges, although contract research is financed from Federal funds and executed by private and public institutions and industrial concerns having unique and singular facilities and skills not otherwise immediately available to the USDA.

The Soil and Water Conservation Research division directs a national research program and related functions in the field of soils, water, fertilizers, hydrology, sedimentation, runoff, design of hydraulic and conservation structures, effects of land use and treatments on conservation of soil and water, engineering design aspects of drainage and irrigation, and the effect on output of alternative systems of conservation farming. It also involves research in soil chemistry, physics, microbiology, and relation of soils to plant and animal nutrition. The Division also compiles data on resources, supplies, production, and consumption of fertilizers and plant nutrients.

This Division provides a limited amount of research assistance to action programs where research data on specific problems are not available. Much of this is in the nature of field tests of soil, crop, and water management practices to meet local situations. It also collects and interprets facts about the influence of land use patterns on runoff, erosion, sedimentation, and flood damage as a means of developing information needed for watershed management, flood prevention, and sediment control in streams and reservoirs throughout the United States.

United States Department
of the Interior
Saline Water Program

GUIDES FOR THE SUBMISSION OF RESEARCH DEVELOPMENT PROPOSALS
PB 161374. Cost of guide 50¢. 1952.

U. S. Department of Commerce
Office of Technical Services (Distributes above brochure.)
Washington 25, D.C.

The Secretary of the Interior under authorization provided by Public Law 448, 82nd Congress, 2nd Session, has established the Saline Water Program. Public Law 448 is an act to provide for research into and development of practicable low-cost means of producing from sea water, or other saline waters, water of a quality suitable for agricultural, industrial, municipal, and other beneficial consumptive uses on a scale sufficient to determine the feasibility of the development of such production and distribution on a large-scale basis, for the purpose of conserving and increasing the water resources of the Nation.

Grants will be made primarily to educational institutions or other non-profit research organizations. Contracts will be negotiated with such organizations and with qualified individuals, industrial or engineering firms. It is expected that grants will be smaller in size and number than contracts, and will be primarily for new and exploratory research with a minimum of fixed guides. Research and development on specific problems with well defined objectives will be performed principally by contract.

DEPARTMENT OF THE INTERIOR
Bureau of Commercial Fisheries
Washington 25, D.C.

Under the Saltonstall-Kennedy Bill funds have been set aside for a wide range of research activities. These funds are administered by the Division of Research Grants of the Bureau of Commercial Fisheries for period up to five years. The instrument used for these grants is a contractual arrangement.

Some of the areas of interest of this group are: oceanographic and climatic influences on the marine environments and changes in water quality as it affects fish and shellfish productivity.

Additional information on this possible source of funds can be supplied by writing to the Director at the address listed above.

DEPARTMENT OF THE INTERIOR
U. S. Fish and Wildlife Service
Washington 25, D.C.

The U. S. Fish and Wildlife Service program of research is carried on under funds from the Dingell-Johnson grant program. Funds under this Act are granted to State Game Departments and are not available to other organizations except through those departments. The Service deals only with the State Departments who are therefore responsible for planning projects, alloting funds and making reports.

It is possible for these departments to allot funds for research in water pollution provided game fish are involved. In as much as the operations of game departments are affected by pollution, funds from this source are a distinct possibility.